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SUBCOMMITTEE ON ANTICIPATED TRANSIENTS WITHOUT SCRAM

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NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON

ANTICIPATED TRANSIENTS WITHOUT SCRAM

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Nuclear Regulatory Commission
1717 H Street, Northwest
Room 1046
Washington, D.C.
Friday, October 22, 1982

The meeting of the Subcommittee on Anticipated Transients Without Scram of the Advisory Committee on Reactor Safeguards was convened at 8:30 a.m.

PRESENT FOR THE ACRS:

W. KERR, Chairman
J. EBERSOLE, Member
D. A. Ward, Member

ALSO PRESENT:

Mr. Davis

Mr. Ditto

Mr. Epler

Mr. Lee

Mr. Lipinski

Mr. Mueller

DESIGNATED FEDERAL EMPLOYEE:

Mr. Quittschreiber

P R O C E E D I N G S

MR. KERR: The meeting will come to order.

My name is William Kerr. I am Subcommittee Chariman of the ATWS Subcommittee. Other Committee members present today are Mr. Ebersole and Mr. Ward. We are also well fortified with consultants, Messrs. Davis, Ditto, Epler, Lee, Lipinski, and the absent Mr. Mueller.

The meeting today continues a long-time discussion of the ATWS problem, with a discussion of a proposed ATWS rule. It is being conducted, as are most meetings, in accordance with provisions of the Federal Advisory Committee Act and the Government in the Sunshine Act. Mr. Quittshcreiber is the Designated Federal Employee in the meeting.

Rules for participation in the meeting have been announced as part of the notice of the meeting published in the Federal Register on September 15 and the one on September 19 of 1982. A transcript of the meeting is being kept, and will be available, as stated in the Federal Register notice. I request that each speaker identify himself or herself and use microphones.

We have not received any written statements or requests to make oral statements from members of the public.

Most of you here have been involved in the continuing discussion and consideration of this problem, and are well equipped with a pile of documentation. We have, it seems to me, made some progress. At least I was gratified to see the set of reports provided by the utility group, because it seemed to me it represented a significant amount of effort to do a quantitative analysis of some of the problems associated with efforts to resolve this issue.

Whether one agrees with all of the conclusions or even the approach, it nevertheless certainly represents a significant effort. It also, I think, might be used by Mr. Bender if he were here as another example of the difficulty of using quantitative PRA to make decisions, but more of that perhaps later, as we get further into discussion.

Before we get to the presentation by Mr. Bernero, who at least will orchestrate the presentation by the NRC staff, I would like to ask each of you or any of you if you have particular issues that you would like to hear treated today. May I ask you if there are any without -- Mr. Lipinski?

MR. LIPINSKI: One of the arguments being promoted is that the suppression pool can be run at an elevated temperature, and I have seen no technical arguments supporting what this means in terms of the maintenance of water level within the reactor vessel and residual heat removal from the containment under these high temperature, high pressure conditions.

MR. KERR: Thank you. Anyone else? Mr. Epler?

MR. EPLER: We have been working on this problem for 14 years, and in accordance with the results of the public opinion poll, the NRC solution is highly unpopular. The proposal is a non-option, and the NRC finds problems with the utilities' proposals, so we have no acceptable solution after 14 years. Why doesn't someone point out that it is in the public interest and the interest of the utilities that we reduce the frequency of transients and demonstrate thereby that we have improved reduced risk? You can't demonstrate 10^{-6}, but you can demonstrate a factor of two, a factor of three, or even a factor of ten reduction in frequency of transients.

I think this is a little overdue.

MR. KERR: I interpret that as a comment rather than a question.

MR. EPLER: It is a question. Why don't we do something?

MR. KERR: Anyone else? Mr. Ebersole?

MR. EBERSOLE: I became first associated with this problem in 1968. At that time, it was impossible to get the industry to recognize the need for a pump trip. I see present here virtually the same arguments used to do anything else beyond a pump trip. I am pessimistic as to the outcome of this meeting, but I will certainly sit here and attempt to hear the issues dragged through again.

One thing that bothers me, I think, a little bit, is the basis of assumptions we put into the calculations as we attempt to assess the probability of this event. It makes me nervous to think of my own assumptive inputs, which tend to be linear in character, being treated as exponentials, and therefore subject to great variability in an output in which such inputs are combined with others.

I am just going to listen.

MR. KERR: Anyone else?

(No response.)

MR. KERR: One of the issues that I would like to have commented on by the utility group, and I think this has been passed on by Mr. Baynard, but if it has not I will repeat it, I found in the report presented by the utility group a number of reasons why the utility group felt that the two proposals that had come out of

NRC were inappropriate. Much of the argument had to do with procedural or legal questions, it seemed to me. There was some argument as to technical problems in the context of NRC requirements. I did not find, although I looked for it, how the utility group reached at least a technical conclusion, either that the risk of ATWS without any fixes was appropriate to the individual operator or the group, or how it reached the conclusion that the risk of ATWS with the proposed fixes was appropriate.

I would be interested in knowing how such a decision was reached on a technical and perhaps even a financial basis, because I think some of the decisions have to be made independently of NRC regulations. The operators of the plants, the people financially and legally responsible, had to reach a conclusion the risk was responsible. I did not see that treated in this document. I wouldn't necessarily expect to see it treated in this document, but I would be interested in some comments on how this sort of decision was reached.

Any other comments from any of you?

(No response.)

MR. KERR: Let's proceed, then, with the agenda, which calls for a report beginning with Mr. Bernero.

MR. BERNERO: Thank you, Dr. Kerr.

First of all, I would like to apologize for my tardiness. I was just down the hall at the Office of Policy Evaluation doing two things, working on a redraft of the Commission policy statement and the implementation plan for the safety goal, and also getting last minute tips on the use of the policy goal and safety goal in the regulatory process, which I will talk to you about in a moment.

You mentioned that Mr. Bender might have a different view on some of the uses of PRA, and ever since he wrote those comments in the ACRS letter, I am inclined to wear a tee-shirt that says SHAM on it, and every once in a while expose it.

What I want to do this morning is review the history of the matter actually using the review of the matter we gave to the Commission just a short time ago in our proposal on how to reach conclusion on ATWS if conclusion could be reached in the near term to end this 14 or 16-year agony of indecision.

We had a meeting with the Commission at the beginning of the summer. I just don't recall the exact date. It was on or about the beginning of June. And we had completed the comment period, and wanted to propose what we thought was a sensible way to come to an end on this, to come to convergence. Now, basically because we did have new Commissioners, and this, of course, is generally superfluous to you because you understand the problem, and many of you have been in it far longer than I or anyone else.

MR. KERR: I thought you were going to tell us after the earlier comments that you were in grammar school when.

(General laughter.)

MR. BERNERO: Would that I could say that.

The important point for the Commissioners to understand is this long history, living with, as Mr. Epler said, the transients, these frequent events that occur regularly in plants. They are the occasion of this question. Even though the event itself, ATWS, is by general measure a fairly low probability event, we are dealing with the challenges that occur very frequently, and the difficulty is that we have two types of failure, electrical and mechanical, and the problem is substantially different depending upon which type of problem you face. Measures to cope with ATWS or measures to make the plant scram even if it failed to scram the first time could be quite different depending upon which type of problem you encountered.

And lastly, the accident sequence has a

characteristic we must always keep in mind. The ATWS sequence is characterized by a surfeit of energy. It is not merely decay heat energy, as all other transient accident sequences have. It is additional generation of power. That is, of course, if you just go to one issue in boiling water reactor ATWS. The recirculating pump trip is extremely important, because by that single act of tripping the recirculating pumps, you have changed the power output of the reactor from 100 percent to 35 or 40 percent just by that single act. So it is this idea of having a surfeit of energy that is very important.

Now, the chronology of ATWS, when we prepared this slide for the Commission, there was a great deal of debate about how to describe this antidiluvian history. There were ACRS reports from a number of consultants to the ACRS, and basically we compromised and just said, "the sixties," you know, in the dim past, the deep forest there, back in the sixties, and then we got into the whole era of the seventies.

And one thing worth singling out for the Commission's attention, and I think it is important for you to recognize, the Commission is expecting, based upon our discussion, I think, to see this regulatory issue confronted in the realm of the safety goal, even though the safety goal is not final. We have a classic use here of a regulatory issue which has traditionally or for a very long time been treated in quantitative, probabilistic terms, and in fact one of the first safety goals ever published by this Commission was in WASH 1270.

Those of you who have never read those reports, and I doubt if there are many who have not, if you forget, go back to Page 16 or 17 of that report, and you will find the one in a million safety goal. It says, if any one sequence has a probability of 10^{-7} per year, and all of them have a probability of 10^{-6} per year of causing a catastrophe, in essence, that society will tolerate it, postulating that there might be as many as 1,000 reactors, and 10^{-5} per year would be a catastrophe per millenium, as a safety goal.

But notice, the WASH 1270 used, as we often have used in the past, a screening criteria like airplane crash. When we look at airplane crash, we speak of the same level, 10^{-6} or 10^{-7}, and we just say, let's presume that rupture of the wall of the containment building is tantamount to catastrophic core melt. You know it is not. I know it is not. But we assume that.

There is a long history of using safety goal thinking in ATWS. The major history of staff analysis was NUREG-0460. It was a four-part document published over a period of years. It constituted the technical basis for what is called the staff rule that went out for comment. There was a Federal Register notice published, to refresh your memory again, at the time the controversial and complicated staff rule was before the Commission. Then Chairman Hendry thought that it might be advantageous to have an alternative, simplified approach, which we have come to call the Hendry Rule, which had the character of being a near-term, modestly prescriptive rule, accompanied by a substantial shifting of responsibility in action to individual owners for reliability assurance programs.

In a way, you could describe the Hendry Rule as saying, look, fix these few things now. Don't argue about it, just fix them, and now show me a sustained program to persuade me that you, the owner, are consciously, currently, and effectively working on ATWS threat, such as reducing transients, looking for design omissions or errors like the scram discharge volume problem in Brown's Ferry, and things like that.

Now, at that Federal Register notice time, we not only have the staff rule, which many people describe as a highly prescriptive rule, we have the Hendry Rule, and we have the Commission notice also cited the proposed utility rule as an alternative, so the Federal Register notice had the character almost of a multiple choice test. It had three proposed rules available for comment.

I think it would be appropriate right here if I said something. I think Dr. Kerr raised the question about the utility group's somewhat ominous statements that the record did not support anything more than the utility group's proposal. When we first got the comments from the utility group along with their major report submittal, we read their comments stated in legalese, stated in the legal comment part, not in the technical reports, that the record was not adequate to support fixes beyond the utility rule, and at first we were concerned about a legal, technical argument.

Actually, I think the question is moot. I do not think we need to focus on that issue. Does the legal record today support any one of these final rule alternatives? I think our lawyers put it best to me when they said, this record is cloudy. The Federal Register notice I just described did not have a proposed rule. It had three drastically different alternative proposed rules. It is a very complex record. Logically, sensibly, the only way to resolve it that seems sensible to us is to extract a decision soundly based and to state what I would prefer to call a proposed final rule, a single, clearly stated, no longer mucked up with alternatives final rule, and put it out for a brief comment period.

It moots the issue of whether or not the legal record is adequate. It is just better rulemaking practice. It is not to say I am postponing the decision, I am walking away from it, I am unwilling to converge. It is to say, look, we have in the comment period of this rulemaking a massive new technical submittal. The staff has engaged in technical activity that adds to that submittal material not in the record when the multiple choice test was published. It is only sensible to have that all in the record, to state a succinct final proposed rule, have a modest comment period, and then get it behind us, enacted.

MR. EBERSOLE: Bob, have you studied the history of the business from, say, '68 to about '73, and attempted to draw from that experience what might be valuable in our current negotiating state now? In that period, for that matter, over the entire 14 odd year period, the only significant physical thing that has taken place in this business is the application of the pump trip. That was proposed in early '68. It was about '73, I think, before the front edge of putting those things on began to start, and only within the last few years did we finish the job up. If we were never able to do anything other than make a prescriptive requirement to put the daggone thing on, we would still be arguing about it.

I see those earlier years as possibly coloring what we have to do today. We will never get a decision without being hard, sharp, and clearly prescriptive.

MR. BERNERO: All right. I will get to a point later on in the presentation about some assumptions we are making in this rulemaking decision process, some limitations we identify, and some strategy, and we speak right to that very point. It is a very significant factor.

MR. KERR: I think some history and some discussion of methods for rulemaking may be in order, but I would like to minimize that.

MR. BERNERO: And get on to the technical content.

MR. KERR: I don't think there are many expert lawyers around this table.

MR. BERNERO: I just want to make the point, I don't see any need to argue whether the record supports one alternative versus the other. I just want to see if the technical fact for regulatory judgment does.

MR. KERR: I am in complete agreement.

MR. BERNERO: I will skip the next vugraph, which is simply a reiteration in vague summary form of the three different rules I just talked about that were published for comment, so again, there was the utility rule, a very simple prescriptive rule, the Hendry Rule, a mixture of simple prescription with reliability assurance, and the staff rule, which is a more complex -- I will call it a performance rule, extensive analysis to show that individual plants meet a performance model, and if you would take the public comments we received and divide them into bins, you would find those speaking in favor of the respective rules or no rule at all are divided as follows.

You can see the utility position rule is supported. There is some redundancy in here. Dave, you could correct me. I think one of these comments actually represents 22 utilities. Isn't that right?

MR. PYATT: That is right. There was one comment from the utility group, but I think approximately nine utilities in the utility group submitted comments.

MR. BERNERO: Then, if you look down here, you can see ten utilities. For the utility rule, ten utilities spoke in favor. Five spoke in favor of the Hendry Rule, 14 in favor of no rule. An interesting point is Other. TVA and one other utility made proposals that were alternatives to those three rules. An interesting point, not that I would take the TVA proposal and throw it out without merit. It is in my mind a symptom of the ATWS problem. I likened it to a Chinese restaurant menu. The ATWS fix has always been such a complicated menu that people can seldom agree even on a set of alternatives. There is always, I want to change one more dish. I want to change one more fix. The result is, here we have out for comment three substantively different alternatives, and two utilities came up with still a fourth and a fifth to choose from. It is a problem we have in this regulatory area, and that we have to live with.

I will also skip the conclusions of the utility group on ATWS, which I presented to the Commission, but I am sure they can present to you here. This is the strategy we proposed to the Commission, and that is, the first order of business was to recognize we had a major new technical data base piece, the utility submittal, generic PRA on individual classes of reactors, that we have to do a technical analysis, as well as a regulatory analysis of that submittal.

We recommended that we would form a task force consisting of representatives of the affected, interested staff offices, nuclear reactor regulation, research, inspection, and enforcement, and in inspection and enforcement, I add the regional offices. I will show you the list in a short time. Administratively, I have the responsibility for the ATWS rule as part of the research office rulemaking development function, but the actual regulatory decision is really shared with the other offices in developing the recommendation to the Commission.

We then said we would take this technical analysis report we would do, and we contracted with Sandia National Laboratories and Energy, Incorporated, who are represented here, to do this technical analysis, that we would review this technical analysis in the task force, and also pass out that report to the CRGR and the ACRS for information so they would have it in advance, and I believe you have received it, the EI report, and the task force would in general try to come to grips with the problem in the following fashion.

Let's consider at least three fundamental alternatives. No ATWS action at all. Put the problem aside and say that ATWS shall be dealt with only in severe accident policy making, the generic consideration of severe accidents, the generic uses of safety goals and probabilistic analysis. In other words, walk away from the problem. That was one alternative.

A second alternative, and this was not presented to the Commission as a single and only choice, but something akin to the utility alternative, a simple, prescriptive sort of rule.

Another alternative would be a more demanding rule, perhaps some consolidation of previous staff alternatives, and that at least we ought to try to converge on alternatives characterized such as this, that we would develop in this task force a consensus, present our position. That would be the staff or office's position. Go through the CRGR process. In parallel, work with the ACRS, and then present the paper to the Commission. Here is the resolution of ATWS.

We formed the task force. I will put the names up here, because many of you know these people and have encountered them. It is actually a two-stage group, the task force, which is the actual workers, the technical specialists, who are doing most of the thinking and the logic, Bob Baer for Inspection and Enforcement, Gary Burdick, who is chief of the Reactor Risk Branch in my own organization, Chuck Graves from Roger Mattson's division in NRR, Warren Minnows, Ashak

Thadani, you know, these veterans of the ATWS battlefield, whose names on this list in June occasioned a poison pen letter about a mindset, that people can't change their minds, and Ernie Rossi, who is in Roger Mattson's division, in electrical instrument control, is a strong contributor to this.

We made some adjustments to the membership of the task force based upon the availability of truly expert people, and Ernie Rossi is one example of that. We added him to the task force in a last minute adjustment, because he was able to bring a great deal to it. For a steering or oversight group, myself, Steve Hanaur, Tim Martin from Region 1 -- he is division director for something like technical -- I can't remember his title, a lead technical division director at Region 1 in King of Prussia -- Roger Mattson, Donald O'Shinsky, who has a similar job to Martin's in Region 2, and Jim Snezack, deputy director of Inspection and Enforcement.

I will show you the schedule we are now on. This is not the same as the one we showed to the Commission in June. We have slipped somewhat. The task force did not converge. In fact, it is delicate. When I get up in the second phase of my presentation, I will be giving you enough information to show where we are going, but we do not now have a voted on final analysis the task force and steering committee endorse. We are very close, and the trend is so obvious that I think it gives you substantive opportunity to comment and object, agree, or whatever you choose to do.

Basically, this part of the schedule, we said we would prepare the technical analysis report and distribute it to the task force. That was met. What we did, the ACRS staff attended the task force meeting. We had the report in draft form distributed to the committee so that additional information needs could be identified, incorporated, and covered before we published it in final form. We wanted to make sure it was adequate, it was complete.

We had originally targeted October 1st, was it?

MR. KERR: Yes.

MR. BERNERO: Yes, October 1st, and this meeting would have been October 5th. We retargeted it to yesterday, and they have the document, but the votes are not in yet. I have to poll each and every member to get those votes, so that I cannot say today I have a consensus, but I think we are very close, and as I say, later on in the day I will be covering that.

We have now just yesterday affirmed the schedule to start the CRGR review on November 3rd. What we will do is, on November 3rd, there will be a briefing of the CRGR giving them the analysis, the decision process, very much of the detail, and then on the following week, November 10th, the CRGR will be presented with the rulemaking paper for ratification. Remember, the CRGR is the EDO's advisor for letting the rulemaking paper go through or not. So we will do that in two stages, the 3rd and the 10th, and we are just now notified we are on the agenda for that.

We hope to complete the CRGR agenda by December 15th, and then give the Commission the paper right after Christmas, the first of the year, and then the rest would be, generally, depending upon comments, advice, and such, we would go through a routine publication, and we postulate now we would put a 60-day comment period on. So, that is the current schedule.

Now, what I would like to do is stop the background talk I have just given and go into the next stage of our activity. It is basically what we just did. I would like to have the contractor, Energy, Incorporated, explain to you the work that was done, the technical review that was done of the utility's submittal. We are a little bit inverted, I think, because the utility submittal will be briefed to you after lunch by the current agenda, but I would like to have our contractor explain what technical work was done.

We have two people here from Energy, Incorporated, Larry Conradi and Bob Bertucio, who will lead off. Do you want to, Larry?

MR. CONRADI: They are passing out a summary of some of the information and findings that we put together. We do not intend to cover all of those charts. It would take more than our allotted time.

One of the things we attempted to do is summarize and collect the information that was in the utility's submittal for ease of review. Some of the information collected there is presented perhaps in a bit of a different format or a different collection of information than appears in the utility report. But hopefully it is a good collection and reproduction of the utility information.

The NRC asked us to provide an objective review of the utility's submittal. As has been mentioned earlier, there are a number of issues and contentions associated with the utility's submittal. We only commented and reviewed on the cost-benefit analysis presented in there, and we did provide a detailed review and evaluation of the application of PRA to this ATWS question. The other questions, regarding policy or legal implications, are obviously not questions we should comment on, so we did not address those directly.

The information that we reviewed was that contained in the utility submittal in the main report and the appendix, the detailed event tree evaluation performed by SAI and the latest update that took place on the 12th of May. In addition to that, the utility representatives were kind enough to meet with us and provide answers to questions we had and provide us additional information or presentation, so that we felt we had an interface with the utility people and a good understanding of the basis for their submittal.

This chart indicates the process that was used in our evaluation and the information that we did review. We evaluated in detail the PRA models included in the utility submittal and evaluated the cost information included.

There was no time to do individual engineering analyses to support some of the contentions or assumptions in the utility submittal. However, it was our intention to point out where information was lacking or where engineering analyses might be required to support some of the assumptions.

We did review in detail the event trees, the initiating events, event probabilities, and how and in what manner the common mode and other things that should be included in a good, competent PRA were in fact included. The idea was to review the process in detail associated with the utility submittal.

Upon identification of those issues, we performed sensitivity studies to try to determine the impact of those issues on the overall argument of the utilities. And we would like to spend as much time as possible addressing those key issues and their impact on the overall results today.

I would like to say a few words in summary about the utility process and our comments on the validity and application of PRA on this issue. The utility representatives I'm sure will cover their process in detail later in the day. But in summary, they performed detailed analyses for each reactor type. They utilized initiating events from the existing EPRI data. They included human errors in one or two cases where it was important to the issue.

The measure of safety or risk that they utilized was unacceptable plant conditions. they utilized these estimates in comparison with other estimates of the Staff and Hendrie rules that were published previously. In fact, it turned out it was quite difficult to make a detailed comparison of the utility evaluation with the previous NRC work, because the utility work was new and certainly in much greater detail than previous work presented by the NRC.

Some comments, then, individually on the validity of the approach and the information generated by the utility in the utility submittal. We felt that the event tree structure adequately represented the ATWS mitigation requirements such that the event tree structure itself was indeed sound.

MR. KERR: Excuse me. What do you mean by "adequately represents the ATWS mitigation requirement"?

MR. CONRADI: From the standpoint of identifying the system responses that must be taken into account, they are adequately included in the probabilistic model itself; that the event tree represents and includes all of the considerations appropriate in the probabilistic structure.

MR. KERR: A number of people commented, and I can't remember, but your report may have been one of them, that in a situation in which one has a very low failure probability that it is not the component failure rate which is most adequately represented by the event tree approach, but the common mode failure rate that may be the larger contributor.

And a number of people commented that there might be some question about whether common mode failure representation was adequate. Did you have any comments on that? When you say "adequately represents", are you including an appropriate or what you would consider to be a valid representation of the common mode failure probability?

MR. CONRADI: I think appropriate in the current state of PRA. As you're well aware, dependent failures and common mode failures are some of the most difficult kinds of events to accommodate in a PRA analysis.

MR. KERR: I am still trying to find out what "adequately" means.

MR. CONRADI: First of all, the comment on the "adequately represents ATWS modification requirements," it is not necessarily addressing component failures or component interactions, but whether or not the event tree structure adequately represents the series of events of the plant response that would be expected to take place following an ATWS event.

MR. KERR: I'm sorry, I don't understand that statement.

MR. CONRADI: In structuring the event trees, it's necessary to identify event headings.

MR. KERR: Yes.

MR. CONRADI: And those event headings best estimate your best estimates of what you think will happen given the occurrence of an initiating event.

MR. KERR: Okay.

MR. CONRADI: The comment here is meant to indicate that the structure defined in the event trees in the utility's submittal --

MR. KERR: Suppose my best estimate is the thing most likely to cause failure is one or more common mode or common cause events. Would I still be willing to say the event tree structure adequately represents that?

MR. CONRADI: I believe you would, because an event tree structure would allow an understanding of those common mode events, and to understand how they can affect the overall outcome of the ATWS sequence.

MR. KERR: So you would not be one of those who would warn that one should still be on the lookout for possible common mode interactions that might have been missed?

MR. CONRADI: No, I certainly would, because of the issue of completeness and the problem of complete identification of those types of factors in a PRA.

MR. WARD: Bill, I think he is saying you should ask a question relative to items 3, 4 and 5, rather than item 1.

MR. CONRADI: The question does apply, and I am sure you will have the same questions in addressing the idea of human factors. And our comment there is, it is an appropriate method.

One of the things we were asked to do and one of the things that was important to the NRC was, how do these guys do their PRA.

MR. KERR: I am not trying to be critical of what you did. I am just trying to find out what "adequate" means.

MR. CONRADI: I guess I understand.

MR. KERR: And I guess it means consistent with the state of the art, and if you got outside of the state of the art you might have some concerns about adequacy. But when you get within the state of the art, those concerns disappear. I think that is what I am hearing you say.

MR. CONRADI: That is correct, that's right.

MR. DAVIS: Excuse me. I have a question also on that item. Your report indicates that for PWR's either manual or automatic boration must eventually occur. Yet you say the utility group did not consider that explicitly in the event tree. Are you now saying that that omission is not significant?

MR. CONRADI: No, I am not saying that at all. This was meant to be a general comment on the structure and the approach for utilization of fault trees in addressing the ATWS issue. The fact that there are specific concerns associated with assumptions that went into the event tree headings or with omissions that may have been left out, hopefully we have pointed that out.

But I am saying that the general structure of the event trees and the manner in which they were constructed tends to be a good consistent PRA approach within the state of the art. As I indicated, the initiator selection was consistent with EPRI 801, the latest issue of that on transient initiating events and event frequencies.

The event probabilities that were assigned to the headings in the event trees were taken from estimates from other analyses. They were not done by detailed fault tree analyses individually. And that is a misprint. It should say "published analyses or engineering judgment".

In general, our observation is that those event probabilities used and assigned to the headings in the event trees are consistent with the results that have been published in many of the numerous published PRA's and the numbers are within a range of reasonableness. In other words, they didn't go out to pick numbers just to suit a specific case. The numbers that are utilized for the event probabilities are based upon other analyses and comparable analyses, so there is some reason to believe that those numbers are supportable, even though the detailed system analysis is not presented.

MR. KERR: Did you have time or did you look at the basic data sources? I am getting used now to seeing a number of comments of the kind you just made about people who do PRA's, and they say, these are consistent with the other published data in the literature. And I am reminded of an article I once read about the propagation of misinformation, in which a paper is published and people start quoting it and pretty soon there is a body of literature to which one can refer, about which one can feel comfortable if he doesn't go back to the basic source.

Did you worry a bit about this?

MR. CONRADI: Yes, we did. I certainly agree with your comment on the repetitive use of the same piece of data. We did look at many PRA's that have been published. We did not just look at one source of data in evaluating the adequacy of those event probabilities.

We also attempted to do some studies to determine the importance of the individual event probabilities, and for those determined to be important by virtue of the percentage they contribute to the sequences and the number of times those event tree headings ended up in the important sequences. We looked at those sources of data more carefully.

MR. EBERSOLE: May I ask a question?

MR. CONRADI: Yes.

MR. EBERSOLE: In looking at the event tree structure, did you look at those fields of events wherein you are really looking for sources, positive sources of ATWS itself, like overvoltage, undervoltage, or fluctuating voltage? I am just giving examples which coincidentally would have a capacity to cause ATWS and at the same time cause a demand for the sprint function.

MR. CONRADI: Those are always some of the more difficult things to include in an event tree analysis, and I would have to say no. We did not have the time to do a detailed search or evaluation of whether or not that type of interfacing type of event was included.

MR. LIPINSKI: Mr. Chairman.

MR. KERR: Yes, sir.

MR. LIPINSKI: These trees were done on a generic basis by a vendor type. What do you conclude with respect to the generic trees versus individual plant trees for the same tree structure, where the numbers going into the tree are not necessarily applicable?

MR. CONRADI: Certainly that's a limitation to the study. In order to be complete, the utility would have had to have provided detailed analysis on every one of the plants they are concerned about. And I think the idea that these are indeed generic trees has to be kept in mind.

Some issues came up as a result of that. We considered that, but the results must be kept in mind that these are generic trees and there can be differences from plant to plant which could affect them, I agree.

MR. LIPINSKI: That goes back to the word "adequately".

MR. CONRADI: Bob?

MR. BERNERO: Excuse me. I wonder if I could interject. I would like to interrupt Larry here.

The question you are raising puts its finger right on the heart of the problem between a prescriptive rule decision process and a performance model decision process. Rigorous engineering tells you over and over again, you do have plant to plant differences, you do have plant to plant variation in many, many respects, and that drives you, if you give that full weight, that drives you toward a decision process which says, here are the criteria and here are the acceptable ways to model analysis of the thing of interest, ATWS, ECCS, whatever it is.

And now as a regulatory act we will go to each and every plant with the performance model, with the set of criteria, and we will have a whole new industry, the ATWS analog of ECCS. Now, that is one extreme.

The other regulatory choice -- and we do this in siting, we do it in many areas. We say, I am going to look at the spectrum of things within the limits of my abilities. And knowing it is not a rigorous decision, I am going to make a prescriptive general choice, a generic choice, and that is the real difficulty.

It is just not practical for us to have the contractor go into each and every plant. We just don't have the resources or the time. So that is the crux of the issue. You are dogged by that uncertainty.

Later on when we speak of injection of boron, when I speak of a BWR-5 or a BWR-6, it has different injection points to question than a BWR-4 or a BWR-3 would. And you have these issues of generic applicability that you must contend with always throughout this.

MR. WARD: Larry, one question before we leave this. Regarding the human factors inputs, you say they are appropriate, what is used in the PRA in general. But included there were what, just errors of commission, errors of omission. Any credit for unusual favorable actions on the part of operators, that sort of thing?

MR. CONRADI: There was in latter stages of the analysis, when utilities brought in the question of the emergency operating procedure. Again, I want to point out that that comment says "appropriate method for inclusion of PRA". They used the WASH-1278 in terms of the limited application of human error analysis, they did primarily in the BWR suppression pool temperature question.

The overall application of human errors and human error analysis, there was not a rigorous, detailed human error analysis done on all aspects of the event trees. It just would have been a very difficult job. On the other hand, the limited applications done here seem to have been done by an appropriate and acceptable method.

MR. KERR: My impression is most people feel more comfortable with treating errors of omission than errors of commission. Is that your evaluation?

MR. CONRADI: Yes, definitely, definitely.

MR. BERTUCIO: Can I make a comment?

MR. KERR: Would you identify yourself and use a mike, please, sir? Just grab one.

MR. CONRADI: I am Bob Bertucio from Engineering, Incorporated.

And before we get this slide off, a comment on the word "adequate" and just what we meant. That slide is structured in the same way you do a PRA. You start with your event tree structure and make success criteria. If you don't have a good event tree structure, any work you do subsequent will be suspect.

What we meant by "adequately represents the ATWS requirement," every systemic or function requirement to mitigate an ATWS event can or is represented by the event tree structure the utilities chose. You can't identify something that must be done in response to an ATWS that I can't find a way to work into that event tree, and that is what we meant by "adequate structure".

Now, what probabilities you pick for each event does not come under the first heading there. All that is under everything else, initiate a selection or event probabilities. And common mode failures between events come under other headings. You said, what if your initiator wipes out a mitigating system. That is all factored into how you pick your event probabilities, and that's other headings.

The first one, for "adequately represents mitigation requirements," I just meant there's not one requirement you could think of that I can't find a way to work into the tree.

MR. KERR: Under what heading do common mode events come?

MR. BERTUCIO: I would say under event probabilities. And your question about initiating frequencies wiping out a system would come under --

MR. KERR: So they are established by engineering judgment, is that what I am to conclude?

MR. BERTUCIO: Yes, yes. The utilities did not do a rigorous -- well, I would say they did not -- they assumed most of the event headings or events were independent, not only that the events were independent from the initiators but there were very little dependencies among subsequent event tree headings or events.

MR. EPLER: Question.

MR. KERR: Mr. Epler.

MR. EPLER: I'm not sure I understand this response. You are saying the BWR, for example, would be expected to see 33,000 demands for a scram under varying plant initial conditions. Now, we can describe some as loss of electric load, loss of vacuum. But among those 33,000 demands there must be a great number that we cannot describe the plant conditions or the interactions taking place as initial conditions, and therefore I don't believe I expect to see those on your event tree.

MR. KERR: Do you understand Mr. Epler's comment or question?

MR. BERTUCIO: No. Where did you get 33,000 demands?

MR. EPLER: Well, 6 a year for 5,000 years.

MR. BERTUCIO: You mean for the next however many years we're going to see however many demands, and we can predict how many it's going to be?

MR. EPLER: You can't describe the initial conditions in the plant for each of those. Some of those you can select as steady state conditions, and under steady state conditions you lose condenser vacuum or electric load, and that makes it fine for analysis. But then you may have conditions of combinations of things, a fire and explosion, operator error, confusion, equipment failure, which are very difficult to put into a tree.

MR. CONRADI: I think we would have to agree with that, and that again falls into the general comment in terms of state of the art and what can really be modeled using the event tree.

MR. EPLER: So I think we are looking at selected models, not necessarily all models.

MR. CONRADI: That's right. Certainly, again, the idea of completeness and complete inclusion is again relative to that, which can adequately be addressed by PRA techniques.

MR. BERTUCIO: Yes.

MR. EBERSOLE: Before you leave the operator action portion of this, could you comment on why the only real heavy part of this that pertains to operator action is initiation of the standby liquid control system on the boilers. I have a little trouble. believing that the operator---

REPORTER: I'm sorry, I couldn't understand that.

MR. EBERSOLE: The standby liquid control system on the boilers.

MR. KERR: Excuse me, that is b-o-i-l-e-r-s and not b-a-w-l-e-r-s.

(general laughter)

MR. EBERSOLE: Oh come on Bill, you all know that I ain't that fer shot. I have a contradictory problem here. How is it I believe that operators won't make a mistake and inadvertently introduce liquid poison into the boilers, and yet will also be competent and always introduce it when they have to? I have a difficulty here in assessing the relative reliability of automated systems versus our operator systems operating under duress, like in one minute.

MR. CONRADI: I understand. We have a sensitivity study that addresses that specifically.

MR. EBERSOLE: Oh, you do? Thank you.

MR. CONRADI: At the risk of engineering a real controversy, I will throw up a slide that shows our analysis of the overall utility submittal and indicating that, within the state of the art and current practice of PRA, the utility submittal seems to be a comprehensive treatment of those things that can be included within a PRA model.

However, our evaluation led us to find that the results of the evaluation are very sensitive to some of the underlying assumptions generally related to the success criteria as defined in the event tree heading. Also, there are uncertainties associated with the cost analyses themselves that can lead to significant variations in the value impact ratios.

MR. KERR: Excuse me. Is that second statement a statement you would make about PRA's generally or is that specific to the particular ones submitted by the utility?

MR. CONRADI: This is a very specific statement relative to very specific success criteria related to the ATWS mitigation requirements and the complement of equipment and the timing associated with them. I might add, there are always questions with regard to success criteria in PRA, but these are very specific ones we have addressed.

MR. KERR: Thank you.

MR. EBERSOLE: Pardon me. Is "value impact" intended to mean the inverse of "cost-benefit"?

MR. CONRADI: Yes, I guess.

MR. EBERSOLE: Why do you use both of these?

MR. CONRADI: Sloppy terminology, I guess.

MR. DITTO: I might comment on that. In the test you said you discarded events where the cost-benefit is less than one, and I think that should be greater than one. The value impact is the other way around. You have it mixed up in the numbers too, I think.

MR. EBERSOLE: That's right.

MR. CONRADI: The last bullet on the chart indicates what we believe to be a good application of PRA in this case. I would like to qualify that and state that I believe the overall application of PRA to this ATWS issue, as was done in the utility comment, is an excellent application of the PRA, excellent in the terms it is used here and the way we evaluated it to focus on the key issues.

I don't know of a better way to sort out the issues that impact the results and their sensitivity than using PRA as a sorting process. There may be questions in terms of the acceptability of the overall sequence numbers or some of the individual event tree headings. There are certainly questions regarding success criteria and the physical reactions of the plant.

But in terms of being able to sort all of those out, I can't think of a better way to do it than utilizing PRA and the PRA models that were constructed here.

A brief slide on the utility's cost-benefit approach. You are familiar with it, probably more familiar with it than me, judging from your comments. There are a couple of points of interest.

One is, the value represents the change in the frequency of unacceptable plant conditions, and the impact is calculated as the cost of implementing the rule. Inherent within those two statements --

MR. EBERSOLE: Pardon me just a second. Does that $10 billion include the cost of probably shutting down the industry for say a year or so or forever?

MR. CONRADI: $10 billion is an interesting number. However, it seems to be one which people have focused on in the past.

Did you have a comment, Bob?

MR. BERNERO: I was just going to say, I expect to treat that very subject in one of my slides, because it is a mushy number.

MR. KERR: I think I can answer that question. The answer is no.

MR. CONRADI: Our look at the cost-benefit analysis told us that there were indeed a number of uncertainties associated with that, and certainly the results of the cost-benefit analysis could be debated or contested because of the assumptions that were included.

The cost of analysis and replacement power certainly dominated the utility cost in terms of comparison with the Staff rule or the Hendrie rule. Keep in mind that there was a comparison on an incremental basis and the change between the rules were compared based upon this absolute ratio; and that the cost estimates of replacement power and analysis were very significant in the estimates of the additional cost of the Staff rule.

MR. WARD: Larry, is that analysis to determine what to do, what changes to make in each particular plant, or is it the generic analysis to justify not doing anything?

MR. CONRADI: It is a generic analysis that must be done each year. I'm sure the utilities will get into the basis for their including those kinds of analysis.

The bottom line on the cost study is that indeed the value impact ratio is sensitive to the various assumptions and definitions, and the idea of whether or not to make a judgment based upon whether or not the value impact ratio is equal or exceeds one, that value itself, that reference number, can be greatly affected by the assumptions that went into the costs, certainly with items such as the cost.

MR. EBERSOLE: Could you define a mitigated ATWS? Is it an undamaged core or something like TMI-2?

MR. CONRADI: That's certainly something very difficult to define in terms of a definable end point. But the idea there was, there may well be costs to the utility of having had an ATWS event that didn't proceed to "unacceptable plant conditions". In fact, the reactor itself and systems could be overstressed, et cetera, and the amount of down time associated an event were not included.

MR. EBERSOLE: On the matter of unacceptable plant conditions, does that include any kind of a thing as long as it is contained?

MR. CONRADI: What was the definition of the end point of an unacceptable plant condition?

MR. BERTUCIO: Unacceptable plant conditions were things like high accident pressure, loss of reactor vessel inventory, things like that, I guess. Does that answer your question?

MR. EBERSOLE: Does it include a contained accident with core damage, heavy, a TMI-2 type of thing? Is that a mitigated ATWS?

MR. BERTUCIO: I guess TMI wasn't an ATWS.

MR. CONRADI: I think that kind of plant condition would be unacceptable.

MR. BERTUCIO: The utilities never talked about containment capability.

MR. EBERSOLE: Well, that is a good thing to talk about.

MR. KERR: Let me suggest you explore this further when the utility makes its presentation.

MR. EBERSOLE: All right.

MR. CONRADI: This chart summarizes some of the key issues that our evaluation of the utility PRA process led us to. I would like to have Bob Bertucio continue the discussion with one chart and a sensitivity study for most of the issues shown on this chart, and I think this will provide a very good basis for a discussion of the very bases for the utility's position here.

MR. KERR: Are there any questions of Mr.

Conradi before he sits down?

(No response.)

MR. KERR: Thank you, sir.

MR. BERTUCIO: I guess to go back and answer your question about unacceptable plant conditions, there were things like in the BWR's high containment pressure, a loss of water level or inventory, or I guess all failures were just classified as unacceptable plant conditions. In a regular event tree, success is up and down.--well, eventually when you get enough failures you go to core damage, or some PRA's call it core melt or something like that. In a full-blown PRA, you take your core damage states and your accident process analysis and containment analysis, you find your offsite consequences.

The utility study just took the unacceptable states or the unacceptable outcomes of the event tree, called those unacceptable plant consequences, and assumed that all of those -- they didn't talk about core damage and such -- all unacceptable plant consequences or all sequences that have unacceptable plant conditions would eventually end up costing $10 billion.

Do you understand? So that is a very conservative approach. It didn't talk about containment capabilities and stuff like that.

This says key issues. It's really more than that. This is a list of all of the things that impact the utility analysis, that impact the probabilities, and the kind of range -- this impacts the BWR's. This is for all reactors, and sort of the ones at the top are the more important, and when you get down here these are the minor concerns.

We will talk about each one here and I will tell you what the utilities did and what the impact is. There are some sensitivity studies here to investigate the impact of different assumptions for each one of these things. I guess I will briefly describe them.

The SLCS failure probability dominated the whole frequency of unacceptable plant conditions, or whatever you want to call them, for the BWR's. Suppression pool. The utilities made a claim of 285 degree supression pool temperature for BWR's. This had an impact on the risk, but there was no supporting evidence or engineering analysis to back this up.

The ratio of electrical to mechanical failures in the RPS is in issue because that determines the effectiveness of an alternative rod injection system. Those are only effective against electrical failures. The utilities assumed a ratio of two to one. This became a key issue in the thing. There is really not much information. We don't have a lot of precursors around to decide exactly what the ratio is, but it is a value of two to one.

MR. DITTO: I am a little concerned that so much emphasis is being placed on this ratio when we don't know what the absolute numbers are. I think it is much more germane to know what the absolute number of failures we are concerned with might be.

MR. BERTUCIO: That's true.

MR. DITTO: And when we apply a rigorous number to an iffy probability overall, it seems too much has been said about the ratio.

MR. BERTUCIO: That's true. But on the one hand, if I'm really certain what the ratio is, if I'm certain it's five to one but I don't know what the -- well, what the probability of an ATWS is, if I know the ratio is five to one, I can tell you with certainty that ARI would reduce the frequency of that by a factor of five.

So I agree, you don't know what the absolute frequency of an ATWS is. That is an uncertainty, and I think this is an equal uncertainty. Yes, it is equal. I wouldn't favor one over the other.

The question of RCS integrity in the PWR's, this issue entails or embodies the, I guess, capability of the PWR primary system to survive the initial pressure spike or pulse.

The next issue is initiation of high-pressure injection in PWR's. This embodies whether you have automatic initiation of HPI or manual initiation, whether your initial pressure spike affects your valve operability.

Do you have a question?

MR. EBERSOLE: May I return back to that ratio of electrical to mechanical failures. With respect to mechanical failures, I believe you treated the PWR's and the BWR's the same way, and yet they have extraordinarily different mechanical systems. I found it difficult to believe that a gravity-induced individualized rod drop function was the same reliability as a non-individualized hydraulic system function composed of intricate mechanical parts and support systems and a host of other things.

By what rationale does one conclude that the PWR individualized rod drop is mechanically no more reliable than the hydraulic BWR system? Have you examined the engineering features of these?

MR. BERTUCIO: No. I could be you sitting there having the same comment. I agree. I didn't assume that they were equivalent. The utility's analysis assumed they were equivalent.

We found the same thing. It is strange to assume. The BWR and PWR systems are vastly different. They were just assumed to be equal.

MR. EBERSOLE: I look to it as a means to an end, and that's all.

MR. BERTUCIO: Yes, yes.

MR. EBERSOLE: All right, thank you.

MR. BERTUCIO: We thought about the differences. There are a lot of differences. You can think all day and you kind of convince yourself the system, the PWR system with the gravity rod drop, is a little more reliable than the BWR system.

MR. EBERSOLE: At least it's individualized.

MR. BERTUCIO: Yes.

MR. KERR: My impression is almost all of the discussion of scram system failure made use of what has come to be called the Staff figure for scram system failure, and it is not a question of anyone having looked mechanically to see that the BWR probability is the same as the PWR probability. It's just the use of a number which has been arrived at on a not necessarily bad, but at least semi-empirical basis.

Isn't that your interpretation of that number?

MR. BERTUCIO: Yes. And you can think about the differences all day, but when you try to quantify them -- well, I guess you could even come to quantitative differences in the system, and then you think about what is the probability of failure to scram in the first place, and that is very uncertain. So it's a nice exercise to think about the inherent differences in reliability, but we are a long way from putting it down on paper as a quantifiable, justifiable difference.

Well, I will just go through the auxiliary feedwater reliability, a comparison of utility analysis and the NRC analysis. To do the cost-benefit studies, the utilities did a lot of detailed analysis for their position and they compared it, they said, for the risk reduction afforded by the Staff rule and the Hendrie rule. We will assume they can get down to 10^{-5} or $^{-6}$, as taken out of NUREG-0460.

And I guess we came to the conclusion that -- I guess it was conservatism -- that the utilities' analysis was a lot more sophisticated than the NRC's analysis.

MR. EBERSOLE: Again, another problem about pouring things into a common hopper. Auxiliary feedwater reliability -- and the concept used in the boiler is of course the HPCI function. Does that include modulated control of level, which is now recognized as a need to suppress the power, or is it just feedwater in any amount? In short, is it a refined, a newly refined requirement on the emergency feedwater system for boilers which is called HPCI? Do you follow me?

MR. KERR: Do you understand the question?

MR. BERTUCIO: I'm not sure.

MR. EBERSOLE: The aux feedwater system on a boiler is called high pressure core injection, and now a push is being made toward modulating the input of that to depress the core leakage, to increase leakage to shut the core down.

MR. BERTUCIO: When you say now, do you mean it's now out on the street?

MR. EBERSOLE: No. The proposal is. That's the way we're going. It is being imposed on the operator as a requirement.

MR. KERR: Let me ask a question which may be clarifying or confusing. Let's see. When you say "aux feedwater reliability" --

MR. BERTUCIO: Oh, this is for PWR's.

MR. EBERSOLE: But I don't see the comparable water supply up there for boilers, but it's got to be up there.

MR. KERR: It's not there. He doesn't consider it a key issue.

MR. BERTUCIO: It's not a key issue.

MR. EBERSOLE: Why not?

MR. BERNERO: Excuse me. I think what you will find when you go into that issue on the boiler is, it appears in the context of the emergency procedure guidelines and the human error rates associated with successful initiation of those procedures and separately successful completion of those procedures, and it comes up in a different context.

MR. EBERSOLE: Bob, if it goes to automation, for instance of standby liquid control, I presume it is also headed for level control of the base PCI or is it not?

MR. BERNERO: No.

MR. EBERSOLE: So that's left to the operator to do.

MR. BERNERO: That's in emergency guidelines.

MR. EBERSOLE: So that is in the operator's function.

MR. BERNERO: Yes.

MR. EBERSOLE: That complicates his already messy lot.

MR. BERNERO: Yes, indeed.

MR. BERTUCIO: Another thing we found is, if you do generic analysis and come to nice conclusions, you may not get the same value impact at each point. There are differences between doing generic differences and specific plants.

We found the two most obvious ones were occurring in the question of operating with a PRV blocked or unblocked and the differences in BWR design, first off in containment designs and secondly in the core design, be it BWR-4, 5 or 6.

And the last thing we want to talk about is cost uncertainties.

MR. LEE: Question. Could you perhaps venture to quantify the difference between generic and specific analyses?

MR. BERTUCIO: My question is with respect to what? You could do a whole PRA on a specific problem that would be different than the generic thing. We did a rough quantification of the difference due to the PORV being blocked or unblocked, and that's the only sensitivity on this issue we did. We are just indicating there are a lot of areas where generic analysis might not be applicable to a specific plant.

MR. LEE: I understand you have performed quite a few sensitivity analyses. Based upon these analyses, I was wondering if you could venture to compare some generic analysis with some specific analyses and quantify possible uncertainties associated with the ASMAX for generic analyses?

MR. BERTUCIO: At this time I wouldn't want to, except with the one limited issue of PORV status, I wouldn't want to quantify the difference.

MR. KERR: Let me push the question one step further, and I would ask you just for judgment, not for a quantitative description. If you had to guess as to which is the larger, the uncertainty in a generic analysis or the difference between a generic analysis and plant-specific analyses, which do you think is likely to be the largest?

MR. BERTUCIO: If I said they were equal, would that be a satisfactory answer?

(Laughter.)

MR. KERR: No.

MR. BERTUCIO: I understand what you're saying. That is a difficult question for me.

MR. KERR: I'm just trying to get your judgment. I'm not trying to ask you to give me a rigorous roof.

MR. BERTUCIO: I would say the uncertainty on the generic analysis is greater than -- let's say, if you did a plant-specific PRA, it would fall within the 95 percent bounds on your generic analysis, and that is my rough guess opinion.

MR. KERR: That's all I'm trying to get. Thank you.

MR. LEE: May I also get some of your own judgments relative to the cost uncertainties? I recognize that you appreciate the certainties and the sensitivity of the cost-benefit analyses due to the uncertainties, but one item that was suggested in discus is related to the cost associated with the analyses.

Now I understand in the utility's report $5 million was assumed and $5 million consists of $1 million for development analysis on a generic basis, and then something like eight reload analyses, each of which is assumed to cost something like $.5 million. Could you comment on whether such an analysis on your suggested basis is reasonable?

MR. BERTUCIO: I cannot comment whether or not that $5 million is a reasonable figure. I do not really know. You know, I do not know. I do not know what it cost to do an analysis, and I do not know how much analysis they are talking about.

All we are saying is the cost of implementation of the Staff rule was heavily affected by this assumed value of $5 million.

MR. BERNERO: Excuse me. Dr. Kerr, there are a goodly number of questions that I would feel a lot more comfortable with the utility group responding to because we are really dealing here with a comment and appraisal of the utility group report, and the utility group spokesmen are here.

MR. KERR: I would agree. These are utility group questions, but I think it is also reasonable to ask someone else whether he thinks the utility group estimate is reasonable. The answer we are getting is he is not sure, and I think that is a very acceptable answer, if that it not the case.

MR. BERNARO: I will also give a regulatory staff comment on it, that the cost of appraisal or analysis in a case-specific way really ought to be looked at in two parts. One, the general numbers they give in that report for the financial cost of doing analysis on an initial and periodic reload basis might be reasonable. They could be higher.

There is also a second element of cost we cannot identify, and that is if we adopt the regulatory approach which depends upon that we will spend another two or three years of our lives conducting such analyses before we get down to business in deciding what to do on their basis, and that is a cost prolonging the ATWS agony, diverting resources both of the utility and the NRC and elsewhere from better tasks.

So that is a cost we cannot quantify. Is it better to select a prescriptive fix that may contain a significant element of error and adopt it, as against trying for a more significant risk, which may involve substantial further delay? How long did we exercise in executing pump trip? The answer was raised by Jess Ebersole earlier.

If we went back in history, instead of muttering over performance criteria or models for analysis, someone should have pounded the table and put out an autocratic rule with a prescriptive fix. Thou shall install a recirculating pump trip. Risks would have been reduced. It would have been reduced and at substantially lower costs.

MR. KERR: I interpret both answers as "I am not sure."

(Laughter.)

MR. KERR: Would you please proceed?

MR. BERTUCIO: SLCS failure probability. This pretty much drove the whole result for the BWRs. About 95 percent of the risk for BWRs could be traced to failure of the operator to initiate SLCS in sufficient time. Those error rates were based upon the time available for SLCS initiation.

The utilities presented two analyses -- one for a 200-degree suppression pool temperature and one for 285. For the 200, they assumed all the operator had to do was initiate SLCS and not tamper with the water level at all. At 285 degrees, he had to reduce water level early in the accident and then restore water level later on in the accident.

Just to give you some ideas of the value, they assumed he had a 99 percent failure probablity if he only had one minute to initiate it, and like a 25 percent failure probability at four minutes, and that goes all the way down to a three percent failure probability if he has an hour to initiate it.

These probability estimates were derived from Swain's work in NUREG-1278. There was a human error curve versus time for actions under high stress and actions under low stress, and the utilities took twenty percent high stress curve and eighty percent low stress curve, and that was the curve they used.

MR. EBERSOLE: Lee, Dade, could I ask your own judgment as to whether you feel such an approach is reasonable?

MR. BERTUCIO: I would say it is a reasonable approach. I would also say that at this stage in the game we really are not absolutely sure about the correct way to incorporate human error probabilities.

MR. LEE: So the only thing you can do is perform sensitivity analyses and then somehow put some error bars, which I have not seen too many of in any of the numbers quoted.

MR. BERTUCIO: It is going to sound like every time you ask a question I say the answer is "I am not certain," and I do not want it to sound like that. Swain has done the most work in the field and has a published systematic way to treat human errors in nuclear power plants. But you will still see a lot of disagreement, conflicting ideas and opinions, and we do not have enough experience to say one is right or wrong.

We are saying they used pretty much the most appropriate method for inclusion of operator errors that we know today.

MR. MOELLER: What is the difference quantitatively between the high stress and low stress curve? You said he took eighty percent of one and twenty percent of the other. What are the differences to begin with?

MR. BERTUCIO: Oh, I do not know offhand.

MR. BERNARO: I have a vugraph of the two curves, if you want to use it, Bob.

MR. BERTUCIO: Oh, yes.

MR. LIPINSKI: On the subject at hand --

MR. KERR: Excuse me, Mr. Bernaro. Maybe you should just give it to Mr. Moeller unless others want to look at it.

MR. BERNARO: I intended to cover it in the logic.

MR. KERR: All right. Why don't we wait for that? Is that all right?

MR. MOELLER: (Nods affirmatively.)

MR. EBERSOLE: Shouldn't there be a subtitle under that -- "errors of commission" -- and then you have a comparable slide -- "errors of omission"? In short, if we have SLCS failure probability in the context of him failing to get it going, we have another set of probabilities that maybe he will get it going when he should not, and that is what GE is worried about.

MR. BERTUCIO: That would not lead to unacceptable plant consequences.

MR. EBERSOLE: It would lead to this extreme damage -- I forgot what the cost of it is now -- that they are trying to avoid by non-automation.

MR. BERTUCIO: Yes.

MR. EBERSOLE: What sort of probability is that? I guess it is worked out later.

MR. BERTUCIO: No, that whole question is not addressed at all.

MR. KERR: Let us interpret this as a comment. I do not think it is really a question on this slide.

MR. LIPINSKI: I have a question on that high stress curve. I tried to place myself as an operator in a plant where I manually have to make a decision to hit that button and realize that the plant will endure a $25 million clean-up cost, and I wonder if we have an appropriate set of numbers to address that kind of decision.

MR. KERR: Mr. Lipinski, I think this is a very good question. Let me suggest that we ask the utility group to address that because I think that it is they who made a judgment as to whether this made sense. I think what has been done here is to say within the field the approach they used is what is being used, whether it is reasonable or not.

MR. LIPINSKI: I will ask it again.

MR. KERR: Yes, I think it is a very valid question.

MR. BERTUCIO: What we did, we did a little sensitivity study for the risk of the total frequency of unacceptable plant conditions, which is vaguely synonymous with risk, versus the SLCS unavailability, and that asterisk means it was averaged over all transients.

There were about six different transients for BWRs. They had different times, and for each different transient there was a different time available for operator action. So there was a different human error probability. And what we have -- this curve represents the 200-degree suppression pool temperature, not the 285. What we have here is, this is the baseline case. This is where the utility analysis comes in right now.

If you were to allow -- and I guess you cannot for this point here (indicating) really allow less reliable operator action. In the baseline case, utilities assume that the operator was just about I will not say "useless", but that he had a one percent chance. For most transients from high power, he had a one percent chance of initiating SLCS in time. That is why this curve does not go further down that way.

If you think your operator is a little more reliable or if you go to an automated system, both of which will reduce the unavailability one way or another, the risk comes down with that curve. This is four times 10^{-5}, and this is about 2.2 times 10^{-6}, so you can use that curve as you want.

We did another sensitivity study --

MR. LEE: May I raise a question?

MR. BERTUCIO: Sure.

MR. LEE: Apart from the obvious sensitivities you are showing here, is there any reason information that one can derive from this vugraph? For example, you gain sort of an order of magnitude in the frequency of unacceptable plant conditions or whatever over the entire spectrum of the unreliability.

What are we supposed to learn from this? Is it useful to try to reduce unreliability or is it not, considering the overall uncertainties and the risk values you have to deal with? Could you comment on that point?

MR. BERTUCIO: Yes. I was going to say different people can look at this curve and get different answers.

MR. LEE: I would like to get your own opinion. You performed the analysis.

MR. BERTUCIO: My first impression is when you get down here, when you come down here (indicating), you do not get a big risk reduction. You can beat SLCS probability into the ground and you still will not get below here (indicating).

When you go from .7 to .1, you are really coming down. This is .1. Maybe it is conceivable to have an operator over-probability of .1. If you give them some more information or more time to act, you might get a human error probability here (indicating). When you get down here, you are talking about automated systems.

MR. LEE: Should I support an automated standby leakage control system, then, or not?

MR. BERTUCIO: I do not know. Should you support it?

MR. LEE: I mean, I find it a little bit disturbing that I see a lot of sensitivity analysis presented without your or EI's judgment on whether these curves are meaningful to support certain items one way or the other. I would like to see some judgment, if possible.

MR. BERNARO: I would like to speak to that. The EI contractors --

MR. KERR: Is that because you do not permit EI to have judgment, or you do not think they have?

MR. BERNARO: I am trying to state the limits they have on their technical work. They are not. We were very careful to remind them of this periodically and we worked very carefully with them.

The contractor has a responsibility to do a thorough, professional, competent technical analysis, but not to make the regulatory judgment. They are going as far as they can to display the technical information germane to that judgment.

MR. KERR: Mr. Bernaro, it seems to me it is pushing things pretty far to ask someone whether he thinks automation would improve the performance and to interpret that as a regulatory judgment. Why is that not a technical judgment?

MR. BERNARO: The relationship between automation and some other parameter of interest can be displayed in a sensitivity analysis.

MR. KERR: Okay.

MR. BERNARO: It is important not to make the choice of automation from that curve. You must look at all of the relevant sensitivity analyses together to make a systematic analysis, a systematic choice, to see the interrelationship of them, and that is the regulatory choice.

MR. LEE: Could I then expect to hear a presentation at a later point on such a judgment of analyses?

MR. BERNARO: Of what judgments drove us, considering the sensitivity curves?

MR. LEE: Or what could we learn from this sensitivity analysis?

MR. BERNARO: Yes.

MR. LEE: All right.

MR. KERR: Please continue.

MR. BERTUCIO: You will notice this thing on the bottom is SLCS unavailability, and I said it has contributors of human error and hardware failure. So we did another curve that broke it out into human error and hardware failure, and now the axis on the bottom is operator error probability and this is for various values of equipment unavailability.

Again you see -- well, it is the same curve. You get a lot of reductions until you start to get down to about .1 and it gets a lot skinnier, depending upon what your hardward availability is, how you have your system configured, if you have two pumps or three. If you are a BWR-4, 5, or 6, you could be at various points on this curve.

The next key issue was suppression pool temperature. The first analysis -- I guess it is fair to call it the first analysis -- that the utilities did assume a 200-degree suppression pool temperature, 200 degrees Fahrenheit, and it allowed very little time for operator action.

Then they submitted an amended utility rule which included emergency operating procedures which required the operator to reduce water level in the vessel, thareby raducing power production, and sparing the suppression pool a little bit. And they also postulated that the suppression pool could survive 285-degree Fahrenheit temperatures.

MR. EBERSOLE: The center paragraph, 285?

MR. BERTUCIO: Yes.

MR. EBERSOLE: It says "subcooling is maintained".

MR. BERTUCIO: Yes.

MR. EBERSOLE: That means the containment has to be pressured.

MR. BERTUCIO: Yes, yes.

MR. EBERSOLE: All right. In the transient the steam discharges are through the down pumps into the suppression pools, so the pressurization of the containment has to be via the suppression pool water evaporating to reduce pressure into the void space the torus, then to the drywell through the vacuum release.

So then the torse water is boiling into the containment. Did you all look at that phenomena and maintain -- did you maintain NPSH on the pumps during the transition process?

MR. BERTUCIO: No, we did not look at it. This is a utility claim. There was insufficient analysis presented in the utility comments for us to examine it. I guess you can direct your questions to them.

MR. EBERSOLE: All right.

MR. BERTUCIO: With the emergency operating procedures and the 285-degree suppression pool temperature, they assumed the operator had twelve minutes for action, that he could wait twelve minutes to initiate SLCS, and his ultimate suppression pool temperature would not go above 285.

And it is called a sensitivity study, but it is not.

MR. EBERSOLE: Do you know what happened at 285 and above?

MR. BERTUCIO: I guess they did not need to go above 285 if you allow twelve minutes. They just made the claim that 285 is acceptable.

MR. KERR: This is an important question, but I think we should explore it with the utilities.

MR. BERTUCIO: What all of this does is it gets you from four times 10^{-5} down to 1.5 times 10^{-5}. The utility analysis did a case for 240-degree allowable suppression pool temperature, and that comes in at about, I think it is, 2.5 or something times 10^{-5}. I am sure they will be able to talk to you better about it this afternoon.

MR. LEE: Let me ask a kind of a generic question, in a way. You see here a factor of three improvement if you assume higher suppression pool temperatures are allowed. Is that factor of three, in your opinion, within the uncertainties associated with the overall risk number, or is it outside of the uncertainty?

MR. BERTUCIO: That factor of three is within the overall uncertainty because the initial value of four times 10^{-5} -- yes, the factor of three is within the overall uncertainty. But I would also like to add if 285 degrees is acceptable, I would believe that going from -- well, I guess that is a real factor of three, if 285 degrees is acceptable.

MR. LEE: When you say "real factor of three", would you care to put an error bar on the factor of three?

MR. BERTUCIO: If 285 degrees is acceptable, there is a slim error bar in the factor of three, because if it is acceptable you do get a lot more time for operator action, and with more time for operator action I think you are fairly certain you will have the lower operator error probabilities.

MR. LEE: All right.

MR. BERTUCIO: But, mind you, I qualify that with "if" 285 is acceptable.

Where are we? Moving on, the ratio of electrical to mechanical failures turned out to be important and, like I said, it was because the supplementary scram systems are effective only against electrical failures. There is a very limited amount of data to go on. The utility analysis. cited three precursors; The Cowl failure in the Brown's Ferry failure and in Monticello.failure. Two were electrical and one was mechanical.and they assumed the ratio was two to one. They added that they feel a more reasonable value is ten to one.

There are probably as many opinions on the true value as there are people in this room.

There was no discussion on difference between the scram systems in the P's and the B's. We did a sensitivity study on just what the impact of all of this was. This is the assumed value, the ratio of mechanical to electrical failures. Right now, we are at two as we come in today, two electrical for every one mechanical. This is a result of the utility rule. First of all, the straight line for the Westinghouse plants is because their utility rule does not propose an ARR or supplementary scram system for Westinghouse plants.

There are two curves here for the GE case at 285 degrees and 200 degrees, and if this two to one is conservative, and the value is more like ten to one, putting in a supplementary scram system is even better than you think, but if we are like ten mechanical to one electrical, we would be down here, and putting it in is hardly worth anything at all, and here again, we aren't here to tell you which values to pick, you know. On the basis of three precursors, I don't think any statistician will give you a hard and fast answer about where you are on the bottom curve.

MR. KERR: Why don't we take a ten-minute break at this point?

(Whereupon, a brief recess was taken.)

MR. KERR: When you are ready to begin, let's start.

MR. BERTUCIO: I have this chart back up, because when I was away for a break, I thought of something. This is an example of what PRA can tell you. People have been asking me, what can you tell me for sure. This is a good use of PRA. Here we are today at two to one, okay? If we make a mistake, and I believe the shape of this curve has no uncertainty. Where it happens to be on the graph is uncertain, but the shape is for sure. We are here today. If we made a mistake, and we are conservative, I mean, if the real ratio is ten to one, we are much better off than we thought. We are right at the knee of the curve, if you think that is the knee. If it is not two to one for something else, I guess we can't get hurt too much. That may be one solid application of PRA.

Taking a value two to one puts us in a nice spot. You can't get hurt too much. But we've got a lot to gain.

The next issue was RCS integrity, and this was the ability of the pressure boundary to survive the initial pressure pump, and this was handled probabilistically on the event tree by the probability of occurrence of an unfavorable -- well, the probability you would have an ATWS when you were at an unfavorable moderator temperature coefficient. The success criteria were defined as not exceeding Stress Level C for Westinghouse plants and Stress Level D for B&W and CE plants.

Event C on the event trees was this event for moderator temperature coefficient, and the probabilities for that even were derived in two ways. For Westinghouse plants, since they did their analysis, since they said they could meet Stress Level C for the 99 percent value of the moderator temperature coefficient, they used a value of .01, and for the Westhinghouse and B&W plants, they used the 95 percent value of the moderator temperature coefficient, but they allowed that for the first three days of the operating cycle when you are starting up for power and not at full power, you are messing around and all of that.

MR. KERR: You mean Combustion and B&W plants rather than Westinghouse and B&W.

MR. BERTUCIO: You are right, and they came up with a value of .104. We did a sensitivity study to show what if, if you choose a different probability of moderator temperature coefficient, or you can think of it this way. This value here is, what is the probability the RCS will survive the initial pressure spike? And for B&W and CE, they chose a 96 probability, and for Westinghouse a 99.

It turns out the task force developed their own probabilities, and I will let Mr. Bernero explain that next. But this study shows you --

MR. KERR: In your view, was any reasonable justification given for assuming that CE and B&W plants were a lot better than Westinghouse pressure vessels and therefore should go up to what is at Stress Level D instead of Stress Level C?

MR. BERTUCIO: No, there was no indication of that, and I must say we did not review any. We didn't get into that. That information wasn't really presented as a part of the utility submittal, and we didn't review it.

MR. KERR: I just wanted to know if you found something that would convince you that was a reasonable difference.

MR. BERTUCIO: No, no.

MR. EBERSOLE: This is just based upon the membrane stress of the vessel. It has nothing to do with the valves, the instrumentation, et cetera. Is that right?

MR. BERTUCIO: That is true.

MR. BERNERO: You are calculating the service level pressure, but whether you use service level C or D or whatever service level as your success criterion is highly dependent on how you deal with the likelihood of valves being jammed and reopening, how you want to deal with the degraded steam generator tubes, and how they might rupture, and so forth. Your success criterion will be the mechanism by which you deal with that.

MR. BERTUCIO: The utility chose to lump all of this under probability of an unfavorable moderator temperature coefficient. You can include other things in there. You can have a .04 for moderator temperature coefficient, but maybe at that value it doesn't assure valve operability, so you can add an extra .1 for messed up valves, or an extra contribution for steam generator tube failure. That is why we did this sensitivity study. You can pick your own value and see what the impact is.

MR. LEE: Could you perhaps explain why in this particular case there could be a little difference in the slope between B&W and Westinghouse?

MR. BERTUCIO: Precisely. The senstivity of the risk with the utility rule. The utility rule has a supplementary scram system for B&W and CE but not for Westinghouse. These folks are off by a factor of three, because when you put in a supplementary scram system, you basically reduce the frequency of ATWS by a factor of three because you can get all of the electrical ATWS's.

MR. EBERSOLE: That seems to answer another question, this modification and improvement to B&W and CE that was not put on Westinghouse. I was first trying to deduce why wasn't it, and you are telling me because it doesn't have as bad an effect on the vessel. Is that right? In short, they didn't feel the need for it?

MR. BERTUCIO: Wait a minute. Wait a minute.

MR. EBERSOLE: I noted the modifications were put on B&W and CE for redundant systems.

MR. BERTUCIO: The scram system.

MR. EBERSOLE: And they were not put on Westinghouse.

MR. BERTUCIO: Right.

MR. EBERSOLE: I took it that Westinghouse thought they didn't need it because their vessel didn't suffer as badly.

MR. BERTUCIO: I really don't know.

MR. EBERSOLE: Was I wrong?

MR. BERTUCIO: I don't know. I guess this afternoon the utilities can answer that.

MR. EBERSOLE: We will find out.

MR. BERTUCIO: The information that came to us said Westinghouse won't do it, and B&W and CE will, and we didn't question as to why. That is how the utility rule has evolved over the years.

MR. EBERSOLE: Did you look at the value of the diversity design they have and agree with the slope of the curve? Is it sufficiently diverse to use a qualifier?

MR. BERTUCIO: The utility submittal we reviewed had very little design information. I cannot say. I mean, I hope -- hope, I expect that if and when it gets installed, there will be other people to assure it is diverse and independent. It is claimed to be a diverse and independent scram system. That is what they propose to put in.

MR. LIPINSKI: When the Combustion Engineering curve is there, is the assumption they had lifts to relieve pressure?

MR. BERTUCIO: Yes. Yes.

MR. KERR: Please continue.

MR. BERTUCIO: Wait a minute. Ask the question again.

MR. LIPINSKI: Combustion Engineering doesn't have enough relief valve capacity. Their position was that the reactor vessel head bolts could stretch and relieve the pressure between the vessel.

MR. BERTUCIO: No, it is not in here. For the

CE plants on the CE event trees, they had another heading. Even if you had success at this event, had a favorable moderate temperature coefficient, at another event tree heading to investigate the probability that you would lift the head, and what was the probability you would l'ft, relieve sufficient pressure, and reseat properly?

MR. LIPINSKI: The peak pressure is directly related to this moderator temperature coefficient, so how can you say this analysis is divorced from the other question?

MR. LEE: I don't understand your answer, either.

MR. BERTUCIO: For CE plants, the success criteria chosen for event V did not preclude a pressure high enough to lift the head. Is that clear?

MR. LIPINSKI: (Nods negatively.) I will have to look at it.

MR. EBERSOLE: You are saying success is to lift the head and vent it, no?

MR. KERR: Let me see if I can understand Mr. Lipinski's question. I think he is saying that in order to accomplish success, one should not exceed Service Level D, and in order not to exceed Service Level D, one has to assume that even with the favorable moderator temperature coefficient, one has a head lift and a relief of pressure by that mechanism. Is that the question?

MR. LIPINSKI: Correct.

MR. KERR: And he was asking, is that the case. I think your head is moving in a direction to indicate yes.

MR. BERTUCIO: Yes, so that is the case. Yes. And I guess the confusion is the way that was represented in the event tree. That is the case, and the way they represented that in the event tree was to have two event headings which deal with pressure relief, one being the moderator temperature coefficient and the other being O ring pressure relief, and I am saying success at this event did not preclude failure at or did not preclude demand at the O ring pressure relief event.

MR. KERR: That sounds clear to me, Mr. Lipinski.

MR. LIPINSKI: Yes. Continue. Peak pressure is directly related to moderator temperature coefficient.

MR. LEE: Yes.

MR. BERTUCIO: Another key issue is the probability of initiation of high pressure injection. This was included because there were two items omitted from probability, and they may have a significant impact. Those two items were the manual initiation of boration and valve operability.

MR. EBERSOLE: Could you refine the first statement, please? Emergency boration required for -- this is PWR's?

MR. BERTUCIO: This is PWR's, yes.

MR. EBERSOLE: Does that mean during the interval of high pressure or after the interval of high pressure.

MR. BERTUCIO: After.

MR. EBERSOLE: And is that a specified value associated with the pump capacity and so forth at that pressure at which you do the emergency boration?

MR. BERTUCIO: Oh, no. I guess we are assuming the emergency boration occurs after the pressure subsides.

MR. EBERSOLE: After you go over the hill?

MR. BERTUCIO: After you go over the hill.

MR. EBERSOLE: So that implies the preceding boration, a relieving function has to take place, depending on this and that, whatever it is.

MR. BERTUCIO: Right.

MR. EBERSOLE: That overrides the pressure transient and takes it down to where you can borate it.

MR. BERTUCIO: Yes.

MR. EBERSOLE: So a prerequisite is to get pressure down.

MR. BERTUCIO: Yes, and so in the analysis at ten minutes you are sitting there, you have survived the initial pressure, you are up in temperature, down in power, and where do you go from there? Eventually, you have to initiate your high pressure injection system. You have to borate.

MR. EBERSOLE: And how is it proposed you get down to lower pressure?

MR. BERTUCIO: Well --

MR. EBERSOLE: You must open something or cool something.

MR. BERTUCIO: Wait a minute. You don't have to. You are there at about 2,400, 2,500, okay?

MR. EBERSOLE: Okay.

MR. LIPINSKI: No, there is some question with respect to the specific plants as to when safety injection can take place with respect to high pressures and the capacities of the pumps, what their pressure ratings are.

MR. BERTUCIO: Yes.

MR. LIPINSKI: The question is, how long do you wait to get the pressure down before you can have high pressure injection? You have to open the PORV to get pressure relief, because if you go on to the safety relief valves, they will automatically reclose, and you have to use the PORV to reduce pressure still further to get to the injection pressure levels that some of these pumps are rated for.

MR. BERTUCIO: I understand what you are saying. This was not addressed in great detail in the utility analysis.

MR. LIPINSKI: It has to be. If you can't get safety injection until you get to a certain pressure, the question is, how much time has elapsed.

MR. BERTUCIO: Wait a minute.

MR. BARANOWSKY: I am Pat Baranowsky from the Reactor Risk Branch. They don't use the PORV to get down in pressure. What they have to have is the auxiliary feedwater system operating. There will be some voids in the primary coolant system after you go through this pressure pulse, because you have blown a lot of water out of the relief valves, and by having the auxiliary feedwater system on, you can then cool the reactor and with less inventory in there the pressure will come down, and at some point you are going to have to have high pressure injection because the temperature in the core will be such that the power would go up again, so you have to have boration occur at a point where you would want to limit that potential return to power after cooling of the auxiliary feedwater system.

MR. LIPINSKI: A part of your fault tree includes the availability of auxiliary feedwater. If it is not available, you get back to the feed and bleed question.

MR. BARANOWSKY: I don't know that feed and bleed was considered a successful operating state for the ATWS analyses. Bob, you can correct me on that. I don't think we have seen any analysis to indicate that could be done successfully. As far as we know, you need to have auxiliary feedwater. If you don't have it, that ends up giving the undesired plant condition.

MR. LIPINSKI: The ultimate event.

MR. BARANOWSKY: Yes.

MR. KERR: Let me ask another question.

MR. BERTUCIO: Is this another question? I want to finish his question.

MR. LIPINSKI: It is done.

MR. KERR: He is satisfied. Don't oversell.

(General laughter.)

MR. BERTUCIO: Okay.

MR. KERR: On Pages 37 and 38 of your report, I don't know whether you have a copy.

MR. BERTUCIO: I wrote it. I think I can remember.

MR. KERR: Okay. I find in the last paragraph on Page 37 the statement, "Boration of the RCS by one of the high pressure injection systems is required for final termination of all ATWS events."

MR. BERTUCIO: Yes.

MR. KERR: And the last sentence in the next paragraph says, "The stability of the plant in this state," that is, a quasi-stable state referred to, "is generally assumed to be maintained for times long enough such that operator failure to initiate boration is negligible." I didn't understand the two statements. They seemed to be in contradiction. One seems to say that boration is required, and the other seems to say if it doesn't occur the effect is negligible.

MR. BERTUCIO: No, what I meant is, boration is required. Boration is required at some time after ten minutes. The analysis goes up to ten minutes. No boration allowed. Some time later on, boration is required, be it 25 minutes, one hour, or whatever, an unspecified time. The value chosen for that event in the analysis, those values were indicative of automatic initiation. They were like .01 and 10^{-3}, and those values are indicative of automatic initiation.

My point was, there was no analysis presented, or that basically, as I said, the analysis therefore assumes that the quasi-stable state you reach after ten minutes was maintained long enough so that either -- it was either maintained long enough so that operator error was essentially small or there was automatic initiation.

By the look on your face, that is not clear.

MR. KERR: Let me see if I understand. The sentence then that reads, "The stability of the plant in this state is generally assumed to be maintained for times long enough such that operator failure to initiate boration is negligible," assumes that you are talking about failure to initiate in some time, not that you are talking about failure ever to initiate.

MR. BERTUCIO: Yes.

MR. KERR: You are going to assume that at some point he will remember it and initiate it, but it doesn't matter too much when. Is that it?

MR. BERTUCIO: First, that statement is my sizing up of the underlying assumptions in the utility's analysis.

MR. KERR: I am trying to understand. You are assuming that -- they have assumed that it doesn't matter too much when boration occurs, as long as it occurs.

MR. BERTUCIO: Yes, yes.

MR. KERR: Is that the point?

MR. BERTUCIO: Yes.

MR. KERR: All right. I understand it, then.

MR. BERTUCIO: I guess the corollary is that if boration is required at some early time, like ten minutes or twelve minutes, as a probabilistic guy, I would expect to see a contribution of human error in the failure probability for failure to initiate, and I didn't see this. I didn't see any human error for boron initiation frequencies.

MR. KERR: All right, I think I understand what you are saying. Thank you.

MR. BERTUCIO: And so there is a sensitivity study as to the impact on the results if you add an additional failure probability due to either human error if manual initiation is required and you added human error or if you have implications of valve unavailability or valve damage due to the initial pressure spike. This is the impact on the frequency of risk of the utility rule with the additional boration failure probabilities, and again, one thing it shows is, it shows what an ARI does for you. It shows what an ARI does for you. It shows what a supplementary scram system does for you.

The B&W and CE curve is kind of flat until out here somewhere, whereas the Westinghouse curve, which does not have the supplementary scram system, doesn't get flat until you get down here (indicating). I will do this quickly, because it turns out this doesn't have as big an impact as you may think. Aux feedwater has a direct impact on risk, because it is required for ultimate determination of all ATWS events. Like Pat Baranowsky said, no feedwater, no core.

The utility rule proposes automatic initiating circuitry for aux feedwater on all PWR's. The reason they did the sensitivity study is, they didn't present any designs in their analysis. They didn't say how the automatic initiation was going to reduce, or how they were going to get from the base line probability to the new improved probability. They did get their probabilities from previous published PRA's, and previously published PRA's have not dealt with ATWS in detail.

The previously published PRA's they got their data from may not have specifically calculated feedwater reliability for ATWS type conditions, or in response to ATWS success criteria.

MR. LEE: I don't appreciate why that point is so important for auxiliary feedwater analysis while it is not for other parameters.

MR. BERTUCIO: What other? I don't understand.

MR. LEE: Why do you have that particular item under the heading of auxiliary feedwater reliability analysis, while you didn't have that point in other sensitivity analysis, for example?

MR. BERTUCIO: Do you mean you want this (indicating)?

MR. KERR: He is saying, what is peculiar about the aux feed system that it would be influenced by an ATWS, whereas other subsystem reliabilities apparently are not.

MR. BERTUCIO: Because they claimed a risk reduction due to reliability improvement in aux feedwater. It was one of the tenets of the utility rule. They said they were going to improve aux feedwater reliability and get a risk reduction, and I am commenting upon the validity of that. They didn't say they would improve the relief valves on the secondary --

MR. KERR: And you are saying, unless they can really improve it, they won't get a risk reduction?

MR. BERTUCIO: Yes, and they didn't say they would improve the main feedwater system or the coolant pumps.

MR. KERR: That seems fair enough. Unless they can do it, they won't get a risk reduction.

MR. LEE: Yes.

MR. BERTUCIO: All of those other systems weren't an issue. Now, what it looks like, the base line case assumes aux feedwater unavailability of .04 for Westinghouse and CE plants, and .1 for B&W plants, and the utility's analysis claims that provision of an auto start circuitry will reduce that to 10^{-3} for CE and Westinghouse plants, and will reduce it to 10^{-4}, no, 5×10^{-3} for B&W plants. And what this study shows is, even if they don't get down here, it isn't really that important. These curves are very shallow here. I will get to this in a minute, but the CE curve actually should be down with the B&W curve, but it just shows that auxiliary feedwater or initiation of it is not all that important as you might think.

MR. LEE: That is somewhat contrary to what you just said in your previous vugraph, that the analysis subject to it is highly relevant to the availability of the aux feedwater system.

MR. BERTUCIO: I didn't say highly.

MR. LEE: Okay, that is my term.

MR. KERR: Would you accept shallowly?

(General laughter.)

MR. LEE: If you follow the onre curve, I can almost neglect the dependence of sensitivity.

MR. BERTUCIO: If I had a slide that said aux feedwater reliability, and my first sentence said, has no reliability effect on risk, I wouldn't continue to talk to you about it. I should say this. I think the question of aux feedwater reliability should be brought up and discussed, and that is what I am doing.

MR. EBERSOLE: Haven't you got to sharply qualify what you are saying when you talk about aux feedwater reliability? For instance, the CE plants have no other means of rejecting heat when they lose heat sink. They have to do that whether they have an ATWS or anything else. So you are talking really about short-term availability in the context of automation and non-automation, aren't you? You are not talking about starting it ten minutes later, like everyone says they can.

MR. BERTUCIO: Actually, no. We are talking about have it or not.

MR. EBERSOLE: Do you mean have it or not in the totality?

MR. BERTUCIO: Long-term, yes.

MR. EBERSOLE: I think we all know a PWR without aux feedwater is in big trouble without feed and bleed, and CE plants don't have it. I guess I can't see the shape of the curve.

MR. KERR: I thought from an earlier comment, Jess, that this analysis doesn't assume feed-bleed in any of the plants.

MR. EBERSOLE: Oh, that's right.

MR. BERTUCIO: Yes.

MR. EBERSOLE: Okay.

MR. LIPINSKI: Going back to my earlier comment, if you can't reduce the primary pressure, you can't necessarily inject boron, and you can't remove residual heat even if you have it shut down. So how do you conclude that you are not sensitive to the availability of the aux feedwater.

MR. CONRADI: I didn't follow the question.

MR. LIPINSKI: Let me start with the sequence. I will give you a symbolized tree. I have a frequency of events for a year. I have the probability that I fail to scram, and the tail end of that is whether I have auxiliary feedwater to continue to get the plant down to normal conditions. If I had no auxiliary feedwater, I have the ultimate event.

MR. KERR: Let me see if I understand. I

thought his question of nonsensitivity was in the context of the difference between .001 and .01 availability, not the difference between that and unavailability.

MR. LIPINSKI: But I don't get a curve of this shape, because I will get a direct proportionality of whatever I take for aux feedwater unavailability into the frequency of event per year. In other words, if I take a factor of ten in aux feedwater I will get a factor of ten in the event.

MR. CONRADI: Let me say this. What this shows you, when you get down here into the lower probabilities, the reason this is flat is there are other things, other events on other graphs that you don't show that are bigger contributors. And it kind of means that when you get up to about .02 or somewhere in here, .06, .08, there are other events whose probabilities are probably up like .1 or 10^{-2} or something.

MR. LIPINSKI: I guess without seeing the tree we can't draw a conclusion.

MR. BERTUCIO: What?

MR. LIPINSKI: Without seeing the full tree we can't draw a conclusion. That is what you are saying.

MR. KERR: That is a reasonable supposition, is it not?

MR. BERTUCIO: Yes. I guess I can draw one conclusion. When you get down to 10^{-3} for aux feedwater, other things are bigger contributors to risk.

MR. LIPINSKI: Okay.

MR. BERTUCIO: And when you get down to 10^{-2} for aux feedwater, other things are still bigger contributors to risk. And the point I want to make about the CE line, the utilities' analysis had an overconservativism in their success criteria, and that is for some transients they require both main feedwater and aux feedwater. And if you remove that and require just one or the other the CE curve will fall down here with the B&W curve.

So this is not really true. It is an artifact of the overconservative success criteria.

MR. KERR: Why don't we go on to the next slide.

MR. BERTUCIO: To do their cost-benefit study, like I said, the utilities assumed that the Staff rule would get you down to 10^{-6} for, I guess, all PWR, Hendrie rules would get you down to 10^{-6}, and the 3A option for the BWR's would go down to 10^{-5}, and the 4A option for the BWR's would go down to 10^{-6}. And this came out of NUREG-0460.

And in the review of the utility submittal it occurred to me that if I took a rather straightforward interpretation of the Staff rule and plugged it into the utility event tree, you may not be able to get down to 10^{-6}, and therefore to use the Staff analysis, which was not documented as well as the utilities' analysis, to use the Staff's analysis to do a detailed utility analysis and then do a NUREG-0460 analysis and compare them might not be an appropriate comparison.

MR. KERR: I can't tell from what you have said whether you have done enough so that you are convinced it won't be a good analysis or you just did a back of the envelope calculation and you are not sure.

MR. BERTUCIO: Well, to say it won't is a strong statement.

MR. KERR: I don't think it's a strong statement if it's true.

MR. BERTUCIO: I gues it all depends upon how you interpret the utility rule.

MR. KERR: Wait a minute. I thought we were talking about what the utility model would demonstrate about the Staff rule.

MR. BERTUCIO: Yes, I guess it depends upon what you take as the Staff rule. Is it 400 gps automatic or --

MR. KERR: You are saying part of the reason for the difficulty is the lack of clarity of just what the Staff rule may be.

MR. BERTUCIO: Here is what I will say. Automating SLCS will not get you down to 10^{-6}. This is plugging your information into the utility PRA model. Automating SLCS won't get you down to 10^{-6}, because after you beat down SLCS maintaining water level inventory is your next dominant contributor and the Staff rule doesn't address that.

Putting relief valves on CE and B&W plants won't get you down to 10^{-6}, okay?

MR. KERR: I understand. That's enough.

MR. BERTUCIO: And I guess that's what those sensitivity studies show. None of those went down to 10^{-6}.

MR. KERR: All right.

MR. BERTUCIO: And the Staff rules just hit the big contributors, not all of them. And after you beat them down, the other contributors show up.

And finally, generic versus specific analysis. We just hit the two big areas here. There are a lot of others. We just didn't have time to quantify all of the differences in plant design. That is why you do plant-specific PRA's.

And I might add, a lot of the PRA's being done now find there are differences between all B&W plants and there are differences between GE plants in design, operation, and which utility owns it. And it's just one of the limitations of a generic analysis. And we found two particular examples here, one in operation with a blocked PORV and the BWR containment design.

I could talk here forever here without coming to conclusions other than specific analysis has less uncertainty than generic analysis. It has to be considered when you are making a decision.

MR. KERR: I asked a question earlier which was, in your view is the uncertainty in the generic analysis bigger in the difference between the generic and the specific. And I thought you said in your judgment the uncertainty in the specific was greater over the generic.

MR. BERTUCIO: I still say yes. But I believe the uncertainty in the generic analysis probably is a factor of ten, maybe a factor of five on either side, something like that.

MR. KERR: If it's that good, I would be surprised. But go ahead.

MR. BERTUCIO: Okay, a factor of ten on either side. But utilities will probably show you cost-benefit ratios. If you will let me change those by a factor of ten up or down, it could make a lot of difference.

MR. KERR: Oh, sure.

MR. BERTUCIO: So I still maintain what I said.

MR. KERR: I just wanted to make sure I understood your earlier comment.

MR. BERTUCIO: But a lot of the cost-benefit ratios are coming out like at .2 or .3, and the decision was being made that was not cost-effective. Well, if it's .3 and you change it by a factor of 3, all of a sudden it is cost-effective.

Finally, the cost uncertainties --

MR. KERR: Excuse me. Mr. Moeller, did you have a question?

MR. MOELLER: I think I will wait until he finishes.

MR. BERTUCIO: The costs were very uncertain. First off, the cost of an ATWS event, $10 billion, what does it include? It's supposed to include offsite damage, onsite damage, the cost of one new plant, the cost of replacement power for many, many years. You could argue about this all day and not come to any conclusion.

This has a direct impact on the absolute value of the cost-benefit ratio. Therefore, the absolute value of the cost-benefit ratio should probably not be used as a primary source of a decision. After you make a decision, it's nice to point to cost-benefit and fortify it, but as the primary d iving force the uncertainty in this won't allow you to use it. However, the ratios of the cost-benefit values -- I guess the ratio one to another still maintain their order. Is that clear?

MR. KERR: It's clear to me what you're saying, but it is not clear to me that I believe you.

MR. EBERSOLE: Let me ask you a question about generic versus specific. A while ago I heard reference to reload analysis, which sounds like a continuing heavy expenditure. In a plant-specific analysis, couldn't one expense bracket the reload ranges and at least be specific enough for one plant and cover virtually all reloads, so you could put it to bed once and for all for one specific plant?

MR. KERR: I think that is a question that is best answered by the Regulatory Staff, Mr. Ebersole.

MR. BERTUCIO: I won't answer that question, but I will give you some information. The utilities assume the Staff analysis would require -- the Staff analysis would basically make ATWS a design basis accident or, if not, close enough to it so they have to do the same level of analysis.

MR. EBERSOLE: That will raise the price of it, of course.

MR. BERTUCIO: Well, yes, yes.

MR. EBERSOLE: I am saying, isn't there a way to avoid that horrendous continuing work by doing a bracketed analysis for a specific plant?

MR. KERR: We will file the question for later consideration.

MR. EBERSOLE: All right.

MR. BERTUCIO: The cost of rule implementation may be plant specific. In fact, the utilities sort of told us they are. They took an average. They had three or four utilities make an estimate of costs for rule implementation and they took an average.

On the one hand, that's what you do for generic analysis. You take an average. It also shows you that value impact may vary from plant to plant. And I guess when you put all of this before this analysis here, the analysis of the cost of replacement power was the dominant cost for the Staff rule and the Hendrie rule, and there's just a lot of uncertainty in that.

And that I guess concludes my presentation, unless there are questions.

MR. KERR: Thank you, sir. Are there questions, Mr. Moeller?

MR. MOELLER: I have been trying to summarize what you call key issues and which may be termed uncertainties. I want to see whether the laundry list of uncertainties that I had was indeed umbrella'ed by yours, and I want to get to a bottom line as to what you think the spread on both the overall risk is and the risk uncertainty is and what you think the overall cost uncertainty is.

And I have plant to plant variability, which has been beaten to death; scram unavailability uncertainty, which refers both to the absolute number as well as the ratio of electric loads to mechanical. I also have cost treatment subjectivity here, which relates more to how one handles analysis costs and replacement costs, and the uncertainty there is not only the absolute value of what these costs are, but how they are derived, how much down time is there really for a given addition or change.

I have cost uncertainties. Five, I have PRA state of the art, and under these I have lumped the things you talked about, including failure probabilities, the big hitters: the standby liquid control system, the aux feedwater system, also the consequence, uncertainties concerning the suppression pool temperatures. And all of this seems to be tied into the human response uncertainties -- high stress, low stress, threshold effects with respect to time. If a guy, if an operator doesn't respond within ten minutes, you really expect him to respond within the next five. Sooner or later there will be some kind of asymptoting out, as well as the absolute number of human response.

One thing that I presume was covered within your uncertainties was plant age effects, including transient frequencies and how these different failure probabilities would be expected to vary with time, whether that was really factored into the scram unavailability.

MR. BERTUCIO: Let me talk on that. It was, but probably not -- you said plant aging effects. The first thing I thought of is, what is the scram probability in the last year of operation or whatever. No one knows yet.

MR. MOELLER: There's a first-year treatment and then the rest of the life of the plant is lumped in. You know, is that valid? What kind of uncertainty does one attach to the total risk as a result of that?

MR. BERTUCIO: What you are talking about now was factored into the utility's analysis.

MR. MOELLER: But you believe the uncertainties -- what uncertainties do you, Energy Incorporated, attach to that?

And the last aspect is nonconsideration of quantitative overall risk impact. I think you call that competing risks. Clearly, there can be gains in other risk areas associated with these changes, as well as there may be risk increase, if you will, because this adversely affects some other accident sequence that may be more dominating.

With respect to the Hendrie rule, how one assigns a risk improvement to a reliability assurance program I don't know. But this was indeed quantified as part of the utilities you have studied. Let me ask three questions, then.

One, have any of the things I have identified -- have they all been lumped in your key issues list, either implicitly or explicitly?

And two --

MR. KERR: Why don't you let him deal with that one.

Do you understand the question?

MR. BERTUCIO: I don't know. Let me say

something and you can tell me if I have answered your question. All of those uncertainties you listed we have identified as being there. I agree with all of those uncertainties there.

MR. MOELLER: Okay.

MR. BERTUCIO: A lot of them are hard to quantify, and I guess we made note of all of those in our analysis and our review, and the more prominent ones are the easy ones to quantify. Actually, we paid more attention to them. But overall we didn't try to put bounds on every uncertainty.

MR. MOELLER: But the things I have mentioned you consider either implicitly or explicitly on your key issues list?

MR. BERTUCIO: Yes.

MR. MOELLER: All right. Taking that, then, I have noticed that the predicted ATWS core melt frequency for BWR's after all is said and done, with the addition of the utility group rule changes, is calculated to be .15 times 10^{-4} per reactor year. Can you tell me what type of uncertainty band Energy Incorporated would attach to that, given all of these key issues or uncertainties and so forth?

MR. BERTUCIO: I don't know. First, we haven't -- and I don't know if I can stand up here and off the cuff give you a qualified opinion.

MR. MOELLER: Where I am going is, there is not only obviously great uncertainty --

MR. KERR: You are saying you have not done enough so that you could attach an uncertainty to it, is that correct?

MR. BERTUCIO: We have not, yes.

MR. KERR: I'm not trying to put words in your mouth. I thought that is what I heard you say.

MR. BERTUCIO: I'm not prepared to stand up here right now and say we have done enough to attach an overall uncertainty to it.

MR. KERR: Did you want to add something?

MR. CONRADI I was going to make that same point. First of all, uncertainties were not explicitly treated within the utilities' presentation itself. There was an attempt at the end of the work to lump the uncertainties, so it would be virtually impossible to comment on the overall uncertainty when it had not been addressed in a definitive manner. There was no propagation of uncertainties throughout all the event trees.

MR. MOELLER: That I understand. But besides coming up with a bottom line risk number of .15 times 10^{-4}, they also came up with a cost number of $11.9

million. Now, embodied within my list, and indeed within your list, are uncertainties that are obviously great on that cost also.

When one looks at the utility group's assessment, one takes the risks, which are uncertain, the costs, which are uncertain, and comes up with a value impact. Basically, do you believe even the relative ranking of the value impacts that the utility group have come up with, in light of the uncertainties? I have a personal opinion that the uncertainty so overwhelms the numbers that one can't tell much.

MR. BERTUCIO: I believe the relative ranking, but I do not believe the absolute value.

MR. MOELLER: The relative ranking, especially with this incremental way of comparing things, favors the utility group changes versus the Staff rule versus the Hendrie rule. Do you think that ranking is much closer or even more disparate in light of the uncertainties? In other words, if you had some kind of a mean value or some kind of a best estimate, do you think the best estimates would be as the utility group has portrayed them, do you think they would be closer or more disparate?

MR. CONRADI: Again, that is a very subjective judgment, and I don't know what you would utilize to base your opinion on other than a purely personal opinion. I would think that in looking at the comparison of the utility evaluation and the Staff and Hendrie rules, that there is such a wide variation you would tend to think perhaps, given the uncertainties involved, that that gap would close up.

On the other hand, the Hendrie rule itself is so uncertain as to even make an estimate. So I really don't think an opinion like that carries much weight. And again, our attempt was to try to identify and pinpoint these issues so that you could look at them individually and then collectively and say, given these issues and these uncertainties, this is what a final opinion or ruling will have to be made on.

MR. MOELLER: Given you don't consider the opinion c[illegible]ies much weight with respect to value impacts, do you think the utility group study with respect to that same comparison carries much weight or should carry much weight?

MR. CONRADI: I think it does, because it does give some information to, as you said, the relative ranking. But clearly, the judgments made in terms of cost of replacement power, the amount of analysis that might be implied, certainly you could change those and close up that gap very significantly, I think.

MR. KERR: Are there other questions? Mr. Lee?

MR. LEE: If I may follow up, at this point what I would very much like to see is sort of a synthesis or convolution of two sensitivy studies: one, reliability versus parametric variations; the second one, the cost-benefit analyses versus parametric variations. And somehow put those two sensitivity studies together and say, okay, I see an overall impact and the difference between the Staff rule and the proposed utility rule would go up or down by some factor.

Have you attempted to do that?

MR. BERTUCIO: I think I know what you're asking for, and we don't have it.

MR. CONRADI: I agree with you, I think that would be very interesting and very helpful to do. But the time did not permit it. The sensitivity studies we did were related to varying one parameter and one parameter only, and I think your idea of a multiple variation and looking at the overall sensitivity to groups or combinations would shed additional light. But there simply was not time available to do that.

MR. BERTUCIO: The question came up. We varied one thing at a time and every time we make a presentation everyone asked to see a different two or three presentations together. There are infinite variations about which parameter you want to see varied, and that is why we were careful only to do one at a time.

MR. LEE: I guess there is a difference between what you are saying and what I was interested in. I wasn't interested in multiple parametric variations or simultaneous variation of multiple parameters. I would be willing to look with single parametric variations each time, but somehow an overall synthesis.

MR. KERR: You want an interpretation rather than the raw data.

MR. LEE: Not a licensing type interpretation, but at least --

MR. KERR: No, but an interpretation.

MR. LEE: Yes.

MR. CONRADI: The primary factpr in the cost-benefit analysis is the delta.in the core damage or unacceptable plant conditions, the change in unacceptable plant conditions, the change in frequency. That is the one variable parameter that is related, and the sensitivity studies we did addressed that specifically. So I think that part of the issue is addressed.

The idea of sensitivity and variations of the uncertainties in the costs, those were not addressed other than pointing out what the uncertainties were.

MR. LEE: May I raise one more question? Have you performed any analysis for pressurized water reactors? If you cannot assume the head lift for B&W and CE reactors and if you have to live with the level C stress, is there a level D? What kind of risk did you get?

MR. KERR: Mr. Bernero, did you want to comment?

MR. BERNERO: Yes. I just wanted to say, when he had his vugraph up speaking of service level pressure he said the Staff chose to go their own way on that, and I was going to cover that. We did not accept service level D as a success criteria and the Staff used service level C, incidentally.

MR. LEE: All right. Thank you.

MR. KERR: Are there other questions?

MR. MOELLER: Yes. Again quoting this, "BWR core melt frequency with utility group changes.15 times 10^{-4}." Presumably, the existing population of BWR plants has some distribution of what the real frequency is, whatever it may be. Where would you put .15 in that population? Do you think 50 percent of the plants are better, 50 percent worse? Please characterize that somehow.

MR. BERTUCIO: Do you mean -- are you saying this is the generic analysis and how does the generic analysis fit if you took all of the specific analyses? If you did a specific analysis on each plant, where would this generic analysis fall?

MR. MOELLER: Yes.

Presumably, one of the things we are supposed to evaluate is the value of the utility group changes. One way of characterizing that value is by this .15 core melt frequency, which is advertised as being conservative. Do you believe it is conservative and would you quantify your statement by saying what percentage of the existing BWR plants would indeed meet that .15?

MR. BERTUCIO: I think I can only say that we have to assume it probably is an average value, and with regard to the BWR population there are differences in plant design, perhaps, that make that question more viable with BWRs than Ps. But given the information we have, I do not know how we could say anything other than the generic analysis that was done we believe fairly represents the general population of BWRs, but recognizing there are variations.

So I can only say I think it is a fair representation of BWRs. Based upon that, I would have to say I guess an average -- there are kind of two numbers. That 1.5 is for the 285-degree suppression pool temperature. There is another number, four times 10^{-5} for a 200-degree suppression pool temperature.

I kind of believe that four times 10^{-5} for a 200-degree suppression pool temperature, because all it is is the initiating transient frequency, which comes from EPRI NP-801, which is a solid chunk of data, and then there is the scram frequency of three times 10^{-5}, and I guess there is uncertainty on that.

MR. KERR: That comes from the NRC, so there is no uncertainty in that.

(Laughter.)

MR. BERTUCIO: And then they give hardly any credit for operator reliability. So that four times 10^{-5} is a reasonable number, I would say, for the variation in the plant. I guess different plants have a different variation in initiating event probability.

MR. KERR: You would accept an answer which says we do not know, would you not?

MR. MOELLER: Yes.

MR. KERR: All right. Next question? Are there other questions?

(No response.)

MR. KERR: Thank you, sir.

MR. BERNERO: Now we get to the funny part. The next stage of our presentation is to go through the decision logic that the task force and the task force steering committee are using in order to conclude our recommendation to the Commission for the resolution of ATWS.

I will be using material either extracted from or directly copied from the analysis document that we are using as the vehicle of agreement, the vehicle of concurrence and statement of view deriving a conclusion. It is a fairly lengthy thing and includes a fair number of event trees. I am going to go through the logic of it, the apparent outcome, the decision logic tables that are there.

I want to show one event tree because I think it illuminates what we are trying to say. I do want to emphasize, though, that I am giving the ACRS as much information as I can. I think I see the outcome. I think you will see how I see the outcome, but what I am presenting is not an endorsed, at this time, task force steering committee thing. I would have given it to you if I had it. We are right at the final polling. We have been iterating it.

That is the reason we have had more meetings than we planned on and more time was required, because at every juncture we looked and said gee, it would be most helpful if we could have one, two or three or more variations on the theme -- further analyses, further sensitivity, further investigation.

That even included extensive discussions of operating procedures for the boilers. It included extensive discussion of the current state of LERs that are significant to ATWS. I call it a "state". It is really a relatively few events, but there have been a few and we paused periodically and went into different issues to some depth.

MR. KERR: Would you be able to guess when the document might be available to the ACRS?

MR. BERNERO: I expect to have concurrence within a week. I obviously have to have it before I go to the CRGR in order to present the case there. I expect to have concurrence within a week, and having it, the thing is typed in final master form, very nearly, now. We are making a couple of changes here and there on an event tree to fill them out, but I would immediately make it available to the ACRS for distribution upon the concurrence.

So let me go back and review our alternatives. If you recall, when we presented it to the Commission, we said well, we really had three rules out there and so if you look at it from a simple cataloging of alternatives, the first alternative is perhaps the coward's way out, and this did look attractive to me, it really did, to take the no-action alternative to seal ATWS in an envelope and pass it on to someone else to worry about.

So it is not really a no-action alternative. It is merely, I would call it, a cop-out. It says I have wrestled with this for fourteen years and I cannot handle it by specific confrontation, so I conclude that it can be better handled if I bury it in that amorphous mass of severe accident considerations -- events beyond the design basis. As I say, it would be convenient, but I do not think it would be a good regulatory choice.

The other three options merely represent the utility group rule, as is or modified fairly close to it, the Staff rule, as it or modified in some degree, and the Hendrie rule, modified or not. We are taking it as it is.

So when we went in there we tried to set down early in the thing. Let's focus our attention on these three alternatives or these two alternatives and not spin our wheels opening the door completely. That did not work, but the task force did not want to converge on alternatives because there is a certain baggage, a certain prejudice when you select an alternative. It is there on the table. It is harder for modifications or for alternatives.

We actually went back to the fundamental description of the threat of the elements of the ATWS problem, and we did not really have alternatives until toward the end. And we went back and talked about the occurrence of transients that challenge the trip system or the scram system. We talked about the reliability or unavailability of the scram or trip system and the ability to cope, to get the reactor process shut down.

We talked of what you might call intermediate mitigating features, and by that I mean relief valves that help a PWR get through the pressure peak, boration systems which turn the thing around, and alternate shutdown systems of one kind or another, which deal with the ATWS before it leads to unacceptable plant conditions where the thing starts to come apart.

Then we also talked about what I would call consequence analysis, which entails other considerations of mitigation, and that is given that you have an ATWS situation, given that you have established or reached a condition of unacceptable plant conditions, service level C being exceeded in a PWR, some pool temperature being exceeded in a boiling water reactor, those are not synonymous with core melt, but we call them unacceptable plant conditions.

You can then try to wrestle with the analysis that will lead you beyond unacceptable plant conditions to full-scale core melt. You can then take full-scale core melt and try to go beyond it to containment failure. You can even do the parametric meteorology analysis to get the actual health consequences. You are wading through a morass of uncertainties wherever you go with that.

It is extremely difficult and I will show you we decided let's look at the elements of ATWS, and let us focus our attention on the front end of ATWS, toward the two aspects of it -- the occurrence and the early mitigation -- that is, relief valves or pressure capability, moderated temperature coefficient -- those characteristics which stand between an ATWS occurrence and unacceptable plant conditions.

So let me first delineate some of the assumptions we have used. I am trying to select from our list of assumptions and analysis the technical information that has been available to us to give you a sense of the logic, but this is by no means a 100 percent complete list. But basically the failure to scram, the unavailability of the scram system is that Staff number that you can trace back to NUREG-0460.

The utility group spoke to it, and Larry Conradi or Bob Bertucio, I think, referred to this also. The utility group quarrelled with the number, arguing that it is conservative, but at the same time made it a give-away and said look, let's not continue the longstanding tradition sanctified over these many years of haggling about that number and not getting on with the problem.

So what the utility group said was we will give you that one. We think it is a conservative value, but we will take it. We will use your number for the failure to scram. So if you would describe the Staff value as a conservative assessment of the failure to scram, which we do not -- we do not consider it a conservative assessment, but if you would describe it as perhaps conservatively biased and theirs as optimistically biased, we are on the conservative bias side of the fence with that.

Now the failures to scram being two-thirds electrical and one-third mechanical, that was covered to some great length in the sensitivity analysis. We did go into the LERs. We did discuss them at some great length and you have the difficulty of saying will I try to select this to describe an unknown reality or will I select this to put myself in a position of regulatory sets.

And after the break Bob read an insight into that sensitivity curve. It is a position when you go to a two-thirds/one-third or a 50-50 or something close to this as a ratio of electrical to mechanical, error or mistake will not hurt you that much. It will not make you that wrong in the direction of the greater threat. In other words, you have given a lot of weight to mechanical threat by this mechanism, and if the mechanical threat is greater, even if it is 100 percent of the threat, you only went up a factor of three in your assessment.

On the other hand, most people, most opinion, suggests that the electrical is likely to the larger one, that you are underestimating the electrical. And what will happen there if electrical is indeed ten-to-one mechanical -- you know, a much higher ratio -- then you have underestimated the value of those steps which deal with electrical ATWS, and you find yourself on the side of the angels.

You have not made a mistake that increases reactor threat. You have merely underestimated the safety equipment effectiveness and, of course, therefore, have overestimated risks. So that seemed a prudent regulatory choice.

MR. KERR: That logic is appealing, but I do not necessarily agree with it. It does have, it seems to me, hidden in it the assumption that one can reduce risk by doing something. I will take that back.

Hidden in the total approach is that one knows how to reduce risk or that, at worst, one will not make the risk any worse if one has miscalculated. Now I wish I were sure of that, because it is also my view that as you complicate things -- and it seems to me inevitably when you put in a diverse system you do complicate things -- you make it more likely that you are introducing some hidden risk.

So I would say I follow your logic up to the point at which you start talking about reduced risks. Then it seems to me it becomes important that you have some idea of where the risk reduction can be achieved.

MR. BERNERO: Yes, I cannot quantify it for you. We cannot quantify it for ourselves. I love to cite a favorite example of a reactor incident late in February 1980. A nuclear reactor was installing an improved safety device -- a saturation meter -- and shorted out two pins and had a loss of DC power to the plant instrumentation which reenacted the Rancho Seco light bulb incident.

It was a competing risk and it was all for the sake of installing a saturation meter. That does happen. We cannot quantify it. We are prone to it. An interesting comment, I think, that we should reflect on, I just came back from a conference in Williamsburg on the regulation of nuclear power, and we were talking about the use of PRA, the use of safety goals in the decision process.

And Chauncey Starr made an observation I think worth recalling. He brought us back to the first reactor PRA that was ever done, which had nothing to do with power reactors. It was a space reactor, and identified from his personal experience in it the value was not in having a good number for risk but illuminating and regularizing the decision process by which risk elements were selected or rejected or passed over or combined.

I think what we are trying to do here, and especially in trying to deal with unquantified uncertainty, is to walk tenderly through this very carefully in presenting these things. But I cannot offer you a rigorous answer that says that logic does not entail some competing risk. I just cannot do it.

Much of this stuff is like that. So the ATWS cost here was a very simple element -- number three there -- $10 billion. The possibilities for uncertainty and sensitivity analysis in the cost are absolutely enormous. I will just touch on some of them.

If you trace that number back -- and it is a number, give-away number. It is another give-away number in an way. It is like this one here. If you trace it back, you can trace that number to NUREG-0460, and if you dig into NUREG-0460 that number seems to be developed solely on the basis of a manrem estimate and multiplication of the manrem by $1,000. It is not a combination of plant damage, offsite damage, monetized health effects, down time, replacement power. It is not some great big, intricate equation.

However, if I went back and said maybe I should do that, maybe I should try that, I could easily reproduce that number for you with a logically-chosen set of plant damage costs, offsite property damage costs, monetized health effects costs, and down time penalties. I could do that. I could generate $10 billion.

I could also generate a number which is much higher if I were to say what I am going to do it carry the post-TMI syndrome to a post-ATWS syndrome and say that if this plant suffered a big bunch of costs because it really suffe..d an ATWS, the whole industry will now be in a snit, and the NRC will make them do a whole bunch of other things, and I will tag that cost into the ATWS event -- an industry-wide escalation of fixes or whatever.

I can make that number go much higher. On the other hand, I can make that number go much lower if I look at it and repeat what I said a little earlier. If I am looking at ATWS, starting from the initiating transient all of the way out to health effects to some individual offsite, if there was an ATWS and a full-scale core melt and release -- a large release -- if I say I am focusing on only the front end of that, the probablity of unacceptable plant conditions.

Someone earlier asked one of the speakers did you include core damage? Unacceptable plant conditions do not constitute core damage. They are not synonymous with core damage. Reaching 200 degrees in the pool local temperature the core is not damaged yet. It might get damaged, but it is not damaged yet. And the service level the same way. You will pop some pins, but I do not consider that a TMI-2-type core damage.

So if I say I am focusing on the ATWS event short of severe core damage, then the $10 billion cost is indeed high because that event is going to have -- oh, I do not know, what is a serious trip worth -- $1 million, a couple of million dollars in some down time? What season was it, that kind of thing.

MR. LEE: May I?

MR. BERNERO: Yes.

MR. LEE: Get some information?

MR. BERNERO: Yes.

MR. LEE: I am somewhat at a loss. These assumptions are going to be used in some way in your decisional analysis?

MR. BERNERO: Yes.

MR. LEE: Could you say a little bit about what the overall logic will be?

MR. BERNERO: I am trying to give you some highlights on the assumptions, some of the limits that we are using as givens, some of the strategy, and then I will show you the decision logic.

MR. LEE: Okay, fine.

MR. BERNERO: One other uncertainty that is a regulatory uncertainty, not a quantitative certainty, that has a very profound effect on ATWS cost is that at the present time in discussions of the safety goal and implementation plan you are undoubtedly aware that the Commission is debating seriously what elements go into the value impact analysis or cost-benefit analysis.

At one extreme I could show you the equation from NUREG-0739, a suggested safety goal structure that was distributed by the ACRS, and it included an equation which counted everything. If you are going to fix a plant to reduce risk and you count the engineering cost of the fix, the down time cost to the plant, replacement power costs associated with shutting it down and fixing it, you would, of course, account for competing risks as well.

Then, on the other side, the averted loss would include the averted loss of plant equipment, the averted loss of replacement power requirements, the averted loss of offsite property damage, the averted loss of health effects. Do we monetize? It is a complete equation.

The Commission safety goal, on the other hand, is $1,000 a manrem. It excludes all of those other costs. There is a great deal of debate about those, and there is also a serious question about the aptness of $1,000 a manrem to represent even health effects costs.

Many people ignore a very important thing. If I use current reactor safety study consequence models, things like the CRAC code or the CRACIT code or the models used in risk analysis, if I use those codes they do give me a calculation, if I wish, of manrem, but they also calculate human health effects, early fatalities, latent fatalities, injuries, those things.

They calculate them based upon a model which is essentially the same as BEIR-3, a sublinear or a linear quadratic dose response model. If I say $1,000 a manrem, it is self-evidently a linear model. That can make a big difference in the consequence. So I have a regulatory uncertainty that pervades that.

The Staff is inclined, along with the utility group, to take $10 billion, since most of the work has been done with it to eliminate the bias or the uncertainty in it and to use it. And that is what you will see. You will see $10 billion used in the value impact analysis.

Further, rather than haggle or argue about the BWR recirculating pump trip, because we did have a long and bitter history on that, we take it as a premise and we merely recognize that whatever rule we would come up with would codify our assurance that the recirc pump trip exists, but we will not sit here and revisit the value impact analysis of recirculating pump trip. So we take that as an assumption.

Now if I go to some limits that come up in highlights of the analysis for PWRs, the moderated temperature coefficient are the limit we set, influenced by what we considered acceptable pressure. We said that Westinghouse plants have a fuel cycle that will be favorable, that is, with respect to the pressure peak size, 99 percent of the time and the CE and B&W plants, 50 percent of the time.

We did have extensive discussion of the selection of that peak pressure. As you know, the utility group proposal included service level D as an appropriate success criterion for the CE and B&W plants. The Westinghouse plants enjoy a large relief capacity and can dodge the question.

In the issue of service level C versus service level D, there are three basic elements that you have to consider in the PWR. One is the reactor coolant system integrity itself, questions like the one raised before. Is the head lifting and acting like a poppet, relieving pressure and then reseating in some reasonably intact form? Is the reactor vessel going to split, multiple LOCAs -- that sort of thing.

The second issue reflects on valve operability. Remember, the point is made that ultimately an ATWS in a pressurized water reactor is shut down by boration, and boration means you will be pumping refueling water, storage tank water, which is 2,000 ppm or thereabouts, and some even higher concentration boron solutions into the plate. You have to come through globe stop-check valves or some kind of valves which will have seen the reverse front of that pressure spike, the pressure pulse. So that comes with the ATWS.

And so the question is what service level is high enough to really challenge the likelihood that a sufficient number of those valves will be open. There are a few cases in the LERs where valves have been stuck by relatively modest pressure pulses. You can go into operating experience. Certainly you can go into valve design. You can easily see how valve pressure can jam a valve.

Lastly, the other element of performance is steam generator tubes. Most of us would agree that a brand-new plant with sound steam generator tubes properly designed, brand-new, ready-to-go, are not in dire danger of rupture if you go to service level C or service level D because they are designed for a steam line break and so forth. A good, sound tube should carry you through with aplomb.

However, if, on the other hand, you are dealing with a real pressurized water reactor somewhere along in its life, you have a condition of steam generator tube degradation that can only be described as that set by the current in-service inspection requirements and tube plugging requirements, and there is a real question, a very difficult question, as to the possibility that a very high pressure spike could lead to multiple steam generator tube ruptures, not just one, two or three, but hundreds, perhaps even thousands, that the level in the tubes might get you into that kind of problem.

In the case of the PWR, the fact that you would thereby bypass containment and raise serious obstacles to successful recovery from that accident, that looks like over the cliff. That is a serious threat.

If I work backwards through those elements, I will say that we chose to use, for our thinking, the limits of service level C on the grounds that beyond that point we had too great a concern about steam generator tube rupture bypassing containment, with hundreds or at least dozens of tubes.

We looked at the valve operability or reoperability consideration and drew a similar conclusion that we were quite confident that up to service level C a reasonable number of valves will still be operating or operable after the pressure spike. One or two might fail, but not everything will fail, and service level D was uncomfortably high for that purpose. It would require extensive analysis and investigation of actual valve types and supporting test data to walk away feeling that service level D could be tolerated with that same assurance.

Lastly, the reactor coolant pressure boundary we did not think was a limiting problem. Ss far as the membrane strength of the reactor coolant pressure boundary, we felt that service level D could be tolerated, but it is the valve in the steam generator tubes that get us to this. So if you go to service level C and look at the information we have, you will come out with a moderated temperature coefficient of 99 percent for Westinghouse and an estimate of 50 for CE and B&W.

There is one other aspect of this worth covering, and that is what will the change in the fuel cycle do to these values and, therefore, to unacceptable ATWS circumstances and its probability. There are a number of places in reactor regulation today where the fuel cycle is subject to change for a variety of reasons. One is with the turnaway from a reprocessing fuel cycle plan to a once-through fuel plan.

There was a very strong incentive -- economic and practical incentive -- to go to high burn-up to get more and more burn-up out of the fuel before taking it out because it is not going to be recycled and you no longer care all that much about the buildup of the plutonium isotopes that are actually poisoning you and so forth.

In addition, you find yourself looking at individual safety problems from time to time, like pressurized thermal shock, which the Committee has heard about recently, where if you would juggle the fuel you could reduce fluids on the reactor vessel welds by putting twice-burned fuel out there in the outer perimeter in the slots closest to the welds.

You have also heard that consideration is being given to take advantage of the $.5 billion worth of information on ECCS we now have by modifying the ECCS rule because there is a good deal of margin in it. If we are willing to modify that rule and reevaluate the parameters of core design, there are a number of changes that would or could lead you to higher burn-up, reduced fluids on the outside of the reactor vessel, and actually, we think, a more favorable moderated temperature coefficient with respect to ATWS.

We do not know.- That is being handled in a number of places and being addressed in a number of rulemaking considerations or regulatory considerations. At least pressurized thermal shock fits that.

So our feeling is this is the right value to choose to describe the reference fuel cycles for these plants, and we think the trend, if anything, away from this will be in a safer direction or a more favorable direction.

The BWR --

MR. KERR: Well, from those comments, is it possible to distill an estimate which says that one could by reasonable use of a burnable poison get moderated temperature coefficients for CE and B&W, in the view of the Staff, that would get one into the 99 percent or 100 percent of the time reach?

MR. BERNERO: We considered the possibility. We spoke of regulating moderated temperature coefficients. If you are willing to go into burnable poisons and also, I think, if you are willing to consider variations in ECCS fuel loading, I think you could go a long way. I do not know you could ever get a current CE and B&W plant up to a Westinghouse level because still it is 99 percent.

MR. KERR: That is the reason I ask. It seems like a considerable step.

MR. BERNERO: We considered it. However, it comes back to the question of analysis. If you would regulate this value, if you would address this as a regulatory parameter, you would then force yourself into a case-by-case analysis and possibly even a reload analysis.

MR. KERR: I am simply trying to determine whether, if an operator chose to go in that direction, it is feasible.

MR. BERNERO: Yes, it is indeed feasible to go a long way. I do not know how far. We do not know how far. Let me go to this one here, the BWR pool temperature.

As was mentioned a little earlier, the pool temperature limit, I can call it, or peak that was covered or mentioned in the utility group report was 285 degrees Fahrenheit. We looked in there. Our consultants looked in there. We could not find sufficient data to justify confidence that 285 degrees F. was a threshold of unacceptable plant conditions.

We looked at it. We discussed it extensively with the Staff people responsible for the relief valve loadings in suppression pool -- what is that, 139? There is an unresolved safety issue that addresses that and recognized over-relief valve loads and pool temperatures. We had extensive discussions of that and came to the conclusion that 200 degrees F. local temperature is not a sacred number.

We are not going to set it down that it must be 200 degrees or less and not 201. We will not use it like 2,220 F. in ECCS regulation. But that is a reasonable definition of unacceptable plant conditions -- not 238 F. That is just too optimistic.

Now highly related to it -- and this is a very difficult logical thing -- is the interaction or interrelationship between pool temperature and human error rate. We used what others cite, NUREG-CR-1278, the human reliability handbook, as a guide. Now here is an excellent -- this curve is made up -- I hope it is legible to you; you have a copy of it in your handout there -- this is the estimated human error rate, human error performance, where error is up and goodness is down and the curves are for persistent high threat; and here is for low stress.

High stress and low stress, you know, are real big problems, and -- wait a minute, I have it so you can see. This is the time in minute. Notice that ten minutes are here right in the middle, 100 minutes at the far right and one minute at the far left. So the time range of interest for an ATWS sequence is somewhere between one minute and, I will say, twelve minutes or fourteen minutes. It depends upon whose model of temperature buildup and which scenario you use.

Well, if you look, then, remembering that ten minutes is in the middle of the curve, the high stress curve derived from the human error performance model of NUREG-CR-1278 says you just cannot trust the operator for a good, long time, quite a few minutes before you can count on him to do anything. The low stress model gives you quite a bit of optimism that after a minute or two he will get his balance, get his equilibrium and he will be a reliable performer.

The SAI contractor in the utility group report used compromise values, the values from between these, and what you are talking about -- this is in the boiling water reactor in particular -- you are talking about three basic human error rate estimates. You have the sequence of events that is really an ATWS and the operator must undertake an evaluation.

He has to figure out what is happening. He has to look at the symptoms. He does not have a red light to go on and say this is an ATWS. He has to decide what situation he is coping with, and then he has to initiate two steps. I am assuming that the SLCS is not automated. He has to do two things.

One is he will turn on SLCS and the other is he will undertake some procedures which we can call ATWS response procedures. He probably has two different error rates, but relatively similar error rates, for those two actions, because his big obstacle is to decide with enough conviction to act that he has an ATWS.

Given that he has decided that, he does have a barrier. Putting boron into the system is not favored by his management. It clutters up the system. It leads to plant shutdown. It is expensive. So he has something of a barrier, a psychological barrier to manual actuation. He has the need to convince himself that he has an ATWS and to overcome whatever residual reluctance he has.

I think he would be somewhat more likely to initiate ATWS procedures than to push the buttom for the slick, but the primary obstacle is going to be deciding that he really has an ATWS and needs to act on it with ATWS procedures, and that will probably put the range of interest out at several minutes -- three minutes, four minutes, very difficult.

Yes?

MR. LEE: Have these human error rate curves been compared with any experience that we have gained in operating power plants?

MR. BERNERO: If you go into the work being done in human factors, there is some comparison of these human error rate curves that has been done and is going on with respect to mockup situations in simulators. I know of that, but I know of no human error rate in plants that has been compared to these models.

Well, the important point is the realm of interest here is that you want to know what can he do in three minutes and four minutes and you are highly sensitive to the choice of these curves, whether you consider that that ATWS is truly a high stress situation or no, it is not that bad if he is trained for it, and he is somewhere in-between here.

Now there is a third error rate. The SLCS, the standard liquid control system, is something that you turn on and it turns. It requires only a modicum of control on his part. The ATWS procedures, on the other hand, are relatively complex and they require the operator to do something that he ordinarily would never do, and that is to starve the reactor.

The whole object of those procedures is to constrain the liquid delivery to the core so that with the recirculating pumps off, with the water level dropping, the generation of power by the unscrammed core is held to a minimum and, therefore, the heatup of the suppression pool is held to a minimum and the operator has more time to turn the thing around and cope with it.

So he has to go through that procedure, an intricate management -- a relatively intricate management -- of water level, the delivery rates, observing the pool temperature, controlling whether he depressurizes the primary system or not when it happens, because when that happens there is a big chunk of enthelpy that leaves the reactor coolant system and goes to the suppression pool.

So the operator now has another human error performance rate you might put on him and that is what is the probability he can successfully carry out those procedures. They are not simply the pushing of a bottom, which is basically what the SLC is.

MR. WARD: Bob, can I ask you a question?

MR. BERNERO: Yes.

MR. WARD: Do you know in this analysis what was assumed about the liquid level information that the operator had?

MR. BERNERO: I cannot answer that question for the operating procedure guidelines. Can someone else answer that? Is it current liquid level information available, or does it require a new --

MR. PYATT: They have liquid level. I think there are some questions of the level oscillating or bouncing around, but they do have.

MR. KERR: The question is what method was in existence or proposed for monitoring, looking at, determining the liquid level?

MR. PYATT: Just visual sighting.

MR. KERR: You are going to install a sight glass in the reactor?

MR. PYATT: No, they have a level, an existing level. I do not think there is any plans to modify the level control.

MR. KERR: Can someone from the utility group verify that? Is the analysis based upon the assumption that you will use existing methods to monitor water levels in the BWR?

MR. BOUGHMAN: I can speak to that. I am Gary Boughman. I am with the Operations Support Center for Pennsylvania Power and Light and hold an SRO license for the Susquehanna station. In the present time in the procedure, the guidance is to use the fuel zone level indicators. If you have a reason to doubt their accuracy, you can also go by indicated reactor power.

A fully covered core at the top of active fuel should give you somewhere around eight percent power. If you feel to maintain eight percent power by borating, you will be going in the conservative direction. You will keep the core covered.

MR. KERR: Thank you, sir.

MR. BERNERO: Thank you.

MR. KERR: Excuse me. Did that complete what you were asking about, Mr. Ward?

MR. WARD: No, but I do not think I am going to get a better answer. That is all right. Go ahead.

MR. BERNERO: When you come back to this curve, remember now we are dealing with the interchangeability of some parameters here: one, the reliability of the operator insofar as he can diagnose the situation and act or, having acted, successfully carry out more complex procedures; secondly, the pool temperature limit for unacceptable plant conditions, because obviously the hotter he can go in the pool the more time he has, the more flexibility, the more capability and, lastly, the rate of boration.

In theory, an infinite level of boration would allow the operator to get out very close to the end of the trail and finally push the button and get all of the boron in the world and pumpf, everything stops except decay heat. It gives him that much more leverage when he finally does decide to actuate the system.

Or, conversely, if you have an automated system, the higher the rate of boron addition, the more flexibility you have to cope with operator error or higher pool temperature. So you have this three-way interaction.

Now what we chose, we looked at these curves, but we considered in the Staff that you cannot hang your hat on them. There is just too much uncertainty and you have to make a judgment as to what degree of confidence you will have in the operator performance. And, as I will show you, we are of a mind that a little more leverage in boron, as well as in pool temperature -- namely the 200-degree F. -- is in order.

Now some strategy in approaching the regulatory decision. We said focus on the probability of ATWS as the figure of merit, and that is consistent with the utility group report terminology, the probability of unacceptable plant conditions, and, of course, you have to explain what your success criteria are. As I said earlier, in our case, unacceptable plant conditions would be a pool temperature of 285 degree F. in the boiler or service level C in the PWR.

Do incremental value impact analysis, look at the elements and not merely at the Staff rule or the utility rule. Try to look a the increments of change for the plant. What does each increment do? What does it really appear to accomplish? In general, use the industry cost figures where they are available and recognize that the value impact analysis will hinge on average costs that could be substantially higher or substantially lower, depending upon the plant and the rate at which implementation is made, the schedule and so forth.

So we have decided to use those figures because it is an intractable problem for us to go out and analyze individual plant costs across the industry, just as it is intractable to do a complete ATWS analysis.

MR. KERR: What is meant by "industry cost figures"? Does that mean the costs in this report or the costs you will collect?

MR. BERNERO: In general, the costs we have collected for industry. If you go into this report you will see substantial presentation of cost data. By "this report" I mean the utility group report. If you go back into NUREG-0460, a Staff document, you will find cost data, much of which is directly in that report traceable to industry source. There were cost figures obtained from the industry.

We tried to avoid making up cost numbers ourselves, but we did have to make up some cost numbers because you will invariably find that one more thing you wanted to do that nobody costed out, and it is vulnerable to the swing from plant to plant. It is a simple strategy.

So sensitivity analyses. You may not understand or be able to quantify your uncertainties, but at least be aware of where the major sensitivities lie.

And lastly, and this is a very important one and it is one which many of the Staff have difficulty living with, and that is we are using a generic analysis which is undoubtedly less certain or less apt to describe a plant than a plant-specific analysis would be.

We are using value impact analysis based upon generic costs. I recalled for you the $10 billion cost of an averted ATWS, which is a very fuzzy number. In spite of all of that difficulty, rather than a performance model analysis we feel it is highly advantageous for the public safety and for the practical regulation of nuclear power to have a prescriptive generic solution, class of plant solution whereby we do not prolong the ATWS agony.

We do not engage in this cycle of plant-specific analysis performance models, possibly even extending into fuel load reanalysis. So this is a strategy thing. This is a strategy choice, that if at all possible, if the confidence can be found, be prescriptive.

And tied to this is an interesting thing. ATWS rules for a long time have come in generations for plants who have received the CP on or before date X do something, for plants whose CP was between date X and date Y do something else, and for future plants so still a third thing or some division like that.

Right now it appears to us that the best way to approach this is existing plants and future plants, where existing plants are those which are already operating or are under construction for operating license. If you look at the present population of plants, there is a dwindling, almost a vanishing, number of plants in that population at the front end of the cycle because of economic conditions -- CPs and so forth.

You will find that almost all of the plants are well under construction, far along in construction, and I recall I had a fresh number on it recently. The number of plants which are still so early in construction that they have not yet filed a final safety analysis report is very small and dropping every day. So the result is if you look at plants, existing plants, pipeline and operating, the issue of backfit flexibility is not worth pursuing. It is just too hard to distinguish the degree of difference.

Let us see, Susquehanna 1 is licensed, is it not?

MR. BOUGHMAN: That is correct.

MR. BERNERO: And Susquehanna 2 is not. It would be an artificial distinction to say I can more readily backfit unit 2 than unit 2. So we are inclined to say that the strategy of this rule should be for existing plants and that future plants should be dealt with separately.

MR. KERR: I do not see why it would be an artifice to say it would be easier to backfit one of those plants than the other. It certainly seems easier to backfit a plant under construction than one in operation for a number of reasons -- maybe less uniform or something, but there is certainly a significant difference between a plant in operation and one which is not.

MR. BERNERO: No. What you are doing, if you take a plant -- well, admittedly you will have different radiation levels in housekeeping and things like that.

MR. KERR: You bet you will.

MR. BERNERO: But you will postpone the availability of the new plant as against suspending the availability of the operating plant, and although there are differences, are they so substantive that you should distinguish them. If you will look at costs, you will find the costs are dominated by the availability of power generation, not by the additional manpower cost to cope with the radiation area and so forth.

The outage time is overwhelming in cost.

MR. KERR: I am also thinking of the likelihood that you will get something installed and tested and have it reliably operating. Your example of the saturation meter still lurks in any example of having to install any complicating mechanization during refueling, but that is my own opinion.

MR. BERNERO: That strategy choice is one that prevails and of course it implies that future plants, at least, would be dealt with in some generic mechanism not unlike what is being discussed with the severe accident policy statement where plant-specific analyses for standardized plants backed up by longer-range changes in the regulatory requirements -- you know, the basic regulations and design criteria -- would be the way to deal with future plants. So that what we are now talking about is, in essence, backfit decisionmaking.

Now let me talk about the use of the safety goal in order to identify PATWS -- the probability of unacceptable plant conditions due to ATWS. We define it that way and in order to compare it to available or possible safety goal and guideline formulations you have to amplify it to fit the equation.

The probability of ATWS times some fraction S will give you the probability of core melt, full-scale core me⟂t, due to ATWS. X is the difference, that unknown difference, between a 200 degee F. pool temperature or a service level C pressure wave and core melt due to that ATWS sequence full-scale core melt.

Similarly, if I take the probability of core melt due to ATWS and multiple it by some other fraction, Y, I can derive the probability of a referance early fatality due to an ATWS sequence. And, as you know, the Commission's safety goal, for instance, defines a criterion for an individual who lives close to the plant with respect to the probability of early fatality, so that this fraction Y includes two elements.

One is given that the ATWS sequence has caused a large-scale fuel melt, what is the probability of large-scale release, namely containment failure, a massive failure of containment. Secondly, there is an included fraction for dispersion, given that there is a large-scale release. What is the probability that an individual, the reference individual for the safety goal purpose, is going to suffer that exposure?

MR. EBERSOLE: Bob, before I forget this, there is a time element in here which I think is peculiar to ATWS. It may not be peculiar to long-term, slow-occuring core melts. It is a part of the thing because it may get in the way of evacuations.

MR. BERNERO: Oh, yes.

MR. EBERSOLE: Are you including that?

MR. BERNERO: Oh, yes, you have to in that fraction. It is very tough to quantify because the variations plant to plant and containment failure probability, the variations in meteorology and population distribution at sites. One of the things -- you know, it is rather interesting.

In the comment period on the Commission's safety goals one of the things that has come out that has not been looked at before closely is the Commission's safety goal describes an individual fairly close to the plant and at a lot of plants there is no such individual. You know, they have a big site boundary or no one lives near the site boundary, and the issue even comes up as to should you postulate a person.

You have to consider all of that, and that too varies dramatically from Indian Point to Palo Verde across a broad spectrum.

Yes?

MR. WARD: Bob, is the letter Y there a number unique to the ATWS sequence or is it a general-purpose

Y?

MR. BERNERO: It would tend to be -- maybe I should best show it to you on the next slide because I do some number ranging. The ATWS sequence is an energetic sequence. Remember, it is not a very slow, over-pressure characteristic.

Now we tried to derive a PATWS criterion by looking at two aspects of the safety goal using the Commission's published-for-comment safety goal core melt and early fatality. If I look at core melt, full-scale core melt is given a value one times 10^{-4} in the Commission's safety goal. Now this is quite arbitrary, but almost a traditional approach. If I am looking at one sequence, I will divide by ten. I will assign or allocate ten percent of the core melt risk to ATWS, and we did it back in WASH-1270 nine years ago, and we can do it again today.

I can thereby derive that the probability of core melt due to ATWS is one-tenth the probability due to core melt, and if I put it down I can say I will use one times 10^{-5} per year as the probability of ATWS criterion and I will ignore that fraction X, the difference betwee unacceptable plant conditions and core melt, full-scale core melt.

I just arbitrarily leave it off of here, although I could try to put it in and get some lower number. I think you will see one is more limited down here and less certain and perhaps more limited.

Now if I look at early fatality, the Commisson's safety goal gives five times 10^{-7} per year.

MR. WARD: You say "ignore" X. You mean you assumed X was one?

MR. BERNERO: Yes, I assumed X was one. If I take five times 10^{-7} per year, discount it ten percent, I now have an equation where PATWS times X times Y -- remember I must consider X here as well -- will give me five times 10^{-8} per year, and I could do my numerical --

MR. KERR: Why do you discount that by ten percent? It seems to me you are doing a double discount when you discount the core melt.

MR. WARD: No.

MR. KERR: You are not?

MR. WARD: They are separate.

MR. BERNERO: They are separate. I am looking for a critera.

MR. KERR: Okay, okay.

MR. BERNERO: I am looking for a criteria. Now in ATWS you do raise a valid point, though. Is it fair to say that the probability of early fatality can fairly allocate ten percent to ATWS? It might be a higher fraction. Those accidents which threaten early fatality are not the slow, over-pressure accidents. They are the high, energetic ones. It might even be rational to assign fifty percent of the early fatality probability to ATWS, something like that, so that this point here of saying a ten percent allocation is an unknown but probably a conservative -- that is, safe side -- bias.

Now, if I look at the X on my fractions with P-ATWS, using this objective, deriving it from 5 times 10^{-8} per year, I can do what amounts to a sensitivity analysis. Let's do an optimistic one. Let's give X .1, saying that only ten percent of the time will P-ATWS, unacceptable plant conditions, lead to full-scale core melt. And let us further say that ten percent of the time will full-scale core melt lead to containment failure.

I can look at extant risk analyses and derive a number on the order of .05 or .06, one-sixteenth, one-twentieth, a number like that, as an index of the dispersion fraction, given a large-scale release. What is the probability that an individual, a given individual, will suffer the early fatality?

So if I do that, if I take the optimistic approach, I would derive a criterion of 10^{-4} per year for P-ATWS. If on the other hand I say, no, I am going to be more pessimistic, I will use a less sanguine approach, I would say X, the probability of large-scale core melt given the unacceptable plant conditions, is one. Make them synonymous.

I will further say that, given large-scale core melt, I will take containment failure as a given, so I assign a fraction one to both and then I have nothing left but the dispersion factor and there I get a P-ATWS criterion of one times 10^{-6} per year.

Looking at this display, we don't have the benefit of the Angel Gabriel coming down to tell us which to pick. It just seems reasonable, considering all of this, that a criterion for P-ATWS on the order of one times 10^{-5} per year is appropriate.

I would like to add a couple of words. Go back, recall the Commission's safety goal or virtually any safety goal proposal you have ever seen. In deriving its safety goal or guideline value, the authors invariably look at things like health risks. Early fatality is analogous to accidental death, latent fatality analogous to cancer death in our society.

They take those risks, which we live with, and they evaluate the potential for nuclear power accident threat changing those risks. No one ever suggests in a safety goal or guideline proposal that 1,000 percent change in health risk is acceptable. They never suggest a 100 percent change or even a 10 percent change in such health risks is acceptable.

Nevertheless, we live with such changes and consider them trivial. We smoke, we move from state to state, we enjoy life habits that give us variations of 200, 300 percent, 400 percent, in accidental death risksand in cancer death risk -- dramatic changes available.

What the authors of these guidelines do is select numbers like one percent or, in this case, one-tenth of one percent. That's where this number came from. Don't ever lose sight of the fact that that is a description of risk, not a limit on risks.

I do not need and will not seek a high level of assurance that that health risk is not exceeded. I see to describe nuclear accident risks for ATWS related to that. There is a big difference. There is a big differencé in how you deal with your uncertainty in that choice.

So we have here a description of P-ATWS that we think is an apt criterion. It is on the order of one times 10^{-5}. Now, if you sit down to try to sort it out on a given plant, you go through a logic chart something like this. And in your handout you will have assumptions and notes with it. I have vugraphs of them which I could put up, but I would just like to walk through the basic logic chart.

It is not something that lends itself to quick display and quick explanation. You need to study it and consider it in the backdrop of the analysis that has been done and is available.

The current commitment is the zero alternative, namely stating clearly what presumptions are being made about recirculating pump trip and so forth and thereby stating what P-ATWS is as a reference, what is today's generic P-ATWS for this type of plant. And here the description of the current commitment is that recirc pump trip is installed, the scram discharge modifications have been made, namely it is the quality assurance program that ensued after the Browns Ferry ATWS of June 1980, were the scram discharge volume was gagged with water, and that the emergency procedure guidelines are implemented and those are being carried on in a separate arena.

The implementation and discussion of what water level instrumentation is appropriate for them and so forth is being carried on in a separate arena, and we don't consider it part of an ATWS decision to make that. We take that as a given. But, as this load indicates, we have grave reservations about the ability of the operator -- about the demand placed on the operator by those procedures. If the operator has at his disposal only a 43 gallon per minute flow and a 200-degree F. pool temperature that it would be prudent to live with, we have grave reservations about the achievability of it.

We then go and try to describe escalations in terms of the utility proposal. Where possible, the primary description is the element you see here. And we tabulate what we believe is the best estimate for the revised P-ATWS, the increment of costs. And the notes will give you the derivation of the cost, and the value impact analysis done on an incremental basis using once again the $10 billion averted cost.

Here, this stage one, the ARI or diverse scram system. You recall, that is the one that really only works on the boiling water reactor to dump the air from the control rods. It doesn't work on an ATWS which would be, say, jammed rods or a plugged scram discharge volume. In other words, it is an electrical fix, highly sensitive to that two to one ratio thing.

The ARI would be worth a lot more if we assumed 10 to one electrical to mechanical ratio. So here is the ARI.

The EPG's are merely mentioned again and carried aloft. But the cost --

MR. KERR: Are you assuming two to one?

MR. BERNERO: Oh, yes, yes. We assume two to one. And I just note that that consequently would give you a reduced effectiveness for ARI. The cost is explained in note A, actually, on the next page, as I recall. And one gets a favorable value impact analysis using again that $10 billion as averted cost.

If you go -- what the utility proposal called for in the new plants, ARI, the procedures and a manual liquid control system which gave the operator greater leverage. We can describe it as an 86 gallon per minute system.

It might also be achieved in many plants by a 43 gallon per minute system if you increase the concentration of boron, the chemical concentration. Usually that would involve adding some strip heaters and some higher concentration solution management things. But the equivalent of 86 gallons per minute or a doubled rate of reactivity insertion, never minding the liquid flow rate, that, given this increased leverage, this greater confidence, in our view would get you down to a P-ATWS of 2.3 times 10^{-5}.

And then if you look at the value impact, it still looks favorable. We had to make a rough estimate on the concentration change. That is not costed out in any source we had available, but it is not a really big number. And you can just see, if you doubled or tripled the number it won't change the value impact all that much.

Lastly, we go to the alternative, alternating the liquid control system at either the 43 gallon per minute flow rate, that rate of reactivity insertion, or 86 gallons per minute or greater, for that matter. And these are the levels achieved.

Now, the value impact could be based upon alternative one or it could be based upon alternative two, and I think it was .2 either way. If you base the increment of automation over manual, it has a value impact ratio of .2, not quite as attractive as the two numbers here, less than half.

So you see, on the boiling water reactor if you look at our criterion of P-ATWS around one times 10^{-5}, this option is clearly below it. This option comes most close to it, but at a somewhat dubious value impact analysis. This option appears to be the more desirable one.

In conjunction with that, you will be getting all of the event trees, and let me just show you that on each one of these alternative considerations there is an event tree drawn. This one isn't in the final fully typed form. As you can see, there is a handwritten note to redo it as above.

You can trace the frequency of the event used into the event tree for the function of the electrical reactor protective system, into the mechanical reactor protective system, the standby liquid control system. And the important thing to illustrate in this event tree is the need to use the event tree to evaluate the relative significance of these human error rates which we have inserted in here.

You can refer these to the curve you saw. This is the probability that within a given time, the needed time -- and that needed time is set by pool temperature and the availability of boration; it doesn't matter how much boron per time you can put in -- within those constraints, what is the likelihood of the operator failing to decide to turn on the switch, to manually start boration? I spoke of that earlier.

Here is the second starting human error rate. We describe it roughly: Throttle HPCI, lower water level to L-2. This is the ATWS pressure water temperature management procedure, EPG procedure guideline level. And you have the likelihood of the operator starting or failing to start that procedure in an adequate period of time.

He can't wait a long time because too much heat is going into the pool. He is losing his margin. The pool temperature constrains how long he has to think about it. And typically, one would expect these to be similar values. That is, once he makes up his mind he is dealing with an ATWS it is quite likely that he will do the two together, he will start the procedures and start standby liquid control at the same time.

Then long-term cooling is a shorthand way of saying he will successfully finish the procedures. Now, you can change this number to reflect, one, your judgment of operator error, operator performance under a given circumstance, or you can change this number because your judgment will change by changing this number up here.

This event tree is for a plant which has an ARI, the emergency procedure guidelines in place, and that rate of boration at hand. That is a big difference between that and a 43. It just buys him some crucial minutes.

So in each alternative case you consider the plant the operator finds and then trace through your sensitivity to his error making judgments on it.

MR. KERR: There's a question over here, Bob.

MR. MOELLER: If you can flip back to your previous slide, you had a probability of ATWS per year per alternative number one of 4.1 times 10^{-5}. Is that basically the utility answer with a temperature limit assumption of 200 rather than 285?

MR. BERNERO: Yes. Remember, that ultimately derives from the Staff probability of scram failure that they gave us, and this has a two to one ratio that affects the effectiveness of ARI, and that is how you get it. And what is it, 4.33 transients per year for that?

MR. MOELLER: Basically, you then bought into the utility assessment, except that you changed the 285 to a 200?

MR. BERNERO: Yes, yes. The pool temperature, we just couldn't live with 285. That gives you a big piece of margin if you do. It gives you a lot more minutes. It's like more boration. It is fungible.

MR. MOELLER: I noticed your impact, your cost of $3.3 million, is something like one-fourth of what the utility came up with. So presumably you differed there.

MR. BERNERO: We based our cost -- the cost per ARI, this particular 3.3, includes hardware, engineering and installation of 860,000, a down time of two days for installation and two days for inadvertent trip at $500,000 per day, operation and maintenance $25,000.

It's in the handout. I'm reading from the second page. We made some adjustments. You can do marvelous things to these costs with the down time assumptions.

When you get into automation, this variable here (Indicating), there is a very real concern about inadvertent operation because, you know, it can be a big down time if that thing turns on. Especially a highly capable system with a high flow rate, if it turns on it can drown you in boron. That is a big costly outage.

What you have to ask yourself is, if someone goes in that direction will they start piling interlocks on it to prevent inadvertent operation, that it will have four bells, eight whistles, and a tick-tock that will warn you for the first ten minutes, "I am about to auto-slick you." And then you wonder if you have achieved anything with it.

MR. MOELLER: What I am really trying to get to on the impact is, did you do your own, totally your own cost studies, or did you take the utility response and say, we don't agree with this particular assumption?

MR. BERNERO: The latter is the more apt description. There were times when we went to the utility, we would not quibble with what they said the engineering cost or the design or the hardware cost. Obviously, we would take that. The crucial points are the outage time.

You see, one of the things worth saying here, there is a trend that we have seen since TMI, since 1979. So many new requirements have been piled onto the conventional maintenance and repair requirements for shutdowns that it is a major operation in nuclear plants today to plan and manage refueling outages or maintenance shutdowns.

The stories abound, and they are really chilling. Plants can point out that for a given refueling outage they will have more workers hired, crafts and people like that on site, than they had at the peak of the construction. That is bizarre, that is really bizarre. And you have to raise serious question about, is that an intelligent way to manage it? Can you handle it?

What we are doing in rule implementation is, rather than six NRC employees going into a closed room and incantation methods being used to come up with an implementation schedule that we will then change every six months on the sixth month, what we are trying to do is get to a mechanism where we agree what you have to do, we agree with a suitable adverb -- promptly or soon -- to describe its implementation, and then work out specifically with the plant when that implementation makes most sense.

Because your valid impact analysis is really subject to that rate of implementation. So when we look at the down time outage, I think the utilities have a tendency to select a down time outage that is more ominous. Obviously, they are biased. We are objective.

(Laughter.)

MR. BERNERO: But they have no way of seeing that we might do that kind of implementation regulation to avoid these bizarre cascading requirements that really give you very severe outages.

MR. KERR: Bob, how much longer is your presentation?

MR. BERNERO: I just wanted to show the couple of other charts in the handout. They are much simpler on the PWR to read, and that will be it. I won't bother going through the individual notes, the Westinghouse alternatives, oh, how nice the relief valves are, you know.

The base case. We start at 2.8 times 10^{-5} P-ATWS and then go up to design. That alternative number one is diverse auxiliary feedwater and turbine trip. There is some debate whether or not the plants actually have that already. Some plants have a turbine trip and auxiliary feedwater startup which they might describe as diverse, but we take it that they don't.

We assign a cost and say, P-ATWS goes down to 3 times 10^{-6} per year with those installed, and the cost is $2.8 million with a favorable -- this is assuming you have to install it and don't already have it or don't have most of it. It is a favorable value impact and gets you nicely down to our criterion, and actually going beyond that point is gilding the lily and of dubious value impact ratio.

If you look at the other plants which have the less favorable moderator temperature coefficient, we treat them together. We feel the difference between them isn't great enough to warrant a different regulatory position. The base case is affected, of course, by that moderator temperature coefficient. It's still service level C, just like Westinghouse.

The diverse scram system is taken as the first alternative, along with diverse auxiliary feedwater and turbine trip. And remember, the turbine trip changes your -- how does it go? The turbine trip is what blunts the peak pressure and the auxiliary feedwater is what turns around the scenario after the peak pressure so you can ultimately get the plant down.

We see a favorable value impact ratio for that. But we are a tad above P-ATWS 2 times 10^{-5}

instead of one.

Going the next step to a diverse scram system, along with the diverse aux feedwater and turbine trip, but now adding improved moderator temperature coefficient. There are two ways you can do that. You can go into the fuel cycle and play games with burnable poisons and all kinds of things like that, or you can get the equivalent of it by brute force, putting more relief valves on the plant.

And we have the notes here which explain the cost here about the values used for that. We don't see a favorable value impact ratio for this. It does, however, get you down well below the P-ATWS criterion of one times 10^{-5}. It gets you half a decade, almost, down below it.

So the alternative one appears to be the best choice here. It is marginal, as you can see. Nature is never kind. It does not give you one simple alternative that takes you in a leap to one times 10^{-6}. So if you walk into it, you would see an ATWS fix here that is a little less than was sought in the first place or somewhat more, but nothing straddling the line.

So I am trying to get my consensus votes on these materials. That appears to be where we will come out and what we will present to the Commission. And of course, the Commission is so sensitive to every aspect of this, and in particular the use of PRA and the safety goal, and you can see that we are actually deriving an acceptance criterion and even an interpretation of that acceptance criterion, my description rather than limitation of risk, interpretation, that I don't consider it self-evident that everyone will rubber-stamp it along the way. I think it will be a significant question.

MR. KERR: Thank you. Are there questions?

(No response.)

MR. KERR: I declare a one-hour recess for lunch. We will begin at five of 2:00.

(Whereupon, at 12:55 p.m., the meeting was recessed, to reconvene at 1:55 p.m. the same day.)

AFTERNOON SESSION

MR. KERR: Our afternoon session presentation will start only when Mr. Knuth gets here, and he isn't yet, but it will be my responsibility to make a report to the ACRS as subcommittee chairman at probably the next meeting, and I would welcome any comments you might have at this point which would assist me in my presentation, particularly if you want to volunteer. If you don't want to volunteer, I will ask for comments.

MR. EPLER: We haven't heard all we are going to hear yet.

MR. KERR: No, but you have never been bashful before.

MR. EPLER: I am not bashful. I am being cautious. I will make a comment. I perceive that the utilities' proposal is being received more favorably than I had realized, and it has one very interesting and useful aspect in that the utilities are proposing to do something themselves rather than to wait until the NRC requires it. This is good.

Now, I have some reservations about the manual induction of feedwater and playing games with the water level covering the core, because I consider that not the way to go. However, I see here an opportunity.

MR. KERR: Excuse me. When you refer to

feedwater in this context, you are talking about the BWR?

MR. EPLER: Yes, of course. I see in this an opportunity for the utilities to do something useful for themselves, and in the public interest, and at the same time continue to keep risks at an acceptable level, and for the PWR's, I just can't imagine why it isn't possible to reduce the power level with a control action without a scram in 90 seconds. That is when the peak occurs. That is when all of the trouble is. I would think there are many ways they could get the power level down substantially in 90 seconds, and I can't imagine why they don't do so, and for PWR's, it is even more important that we find some means of reducing the power level, and possibly avoiding the scram transient which costs half a million dollars six times a year.

We had in the beginning from GE a proposal for reloop, which would dump steam into the torus and avoid the scram. Now, there may be some good reasons for not adopting that, but I can't see any good reason for not going back and saying, we don't like that scheme, come back with some more. It is in everyone's interest to save a half a billion six times a year by not having the need for a scram.

I can't imagine why this program doesn't invite and urge utilities to get smart, act in their own interest, and reduce the frequency of transients and demonstrate that they have done so. I think here we have an opportunity to get something started in that direction, and it must be evolutionary. You can't do it by legislation or edict overnight. It must be done slowly and gradually, and the utilities have to do it.

MR. KERR: I think all of those are cogent comments.

Is Mr. Knuth here yet?

VOICE: No.

MR. KERR: Is he on his way? Does anyone know?

VOICE: He is on his way.

MR. KERR: Would anyone else be willing to volunteer some comments?

MR. EBERSOLE: Bill, I would like to have, if possible, an independent investigation made of the assessment of the impact that I see here, because I think there are some distortions in it. Maybe that is intuitive, experience, or whatever, but just looking at some of the numbers, I can't help but think they have been inflated substantially toward the desire to do as little as possible in installing mitigating systems.

To take a particular case in point, I hope I understand what the ARI installation is, and someone can correct me if I am wrong. It is some solenoids using energized operation to bring down air supplies and get a common scram air dump as a result of this, which, of course, always includes a line delay or shutdown, and I wonder why that should be the case, which is $1 million in its own right, brings the total for putting those, I believe, two site solenoid valves in the plant with associated wiring, design, and other costs, up to $3.3 million.

MR. KERR: What sort of independent investigation would you consider to be feasible or acceptable? For example, if we could persuade one of our fellows to do some looking between now and the next meeting, is that something you would have in mind?

MR. EBERSOLE: That might be the way to go.

MR. KERR: Or are you suggesting we ask the NRC to get a contractor to do an independent assessment?

MR. EBERSOLE: I would rather do the latter. In short, I would like to go into an assessment of the realisms.

MR. KERR: What would constitute independence, in your view?

MR. EBERSOLE: They would be doing it under contract for NRC.

MR. KERR: So that you would want someone to go out and collect cost figures from someone other than the industry.

MR. EBERSOLE: I would like to have it be d e from the supply industry.

MR. KERR: Mr. Bernero, did you want to make a comment?

MR. BERNERO: Yes. If I understand the concern, it is that the possibility that the impact of installing ARI is overstated, because at least some plants already have an ARI or what could be described as an ARI. Is that a fair characterization?

MR. EBERSOLE: Yes, and also the fact that ARI's are quite simple.

MR. PERNERO: Yes, it is a relatively simple thing. As it turns out, if we could get someone to go out and catalogue all the plants which have and don't have an ARI and get an even better figure of numbers, probably lower, certainly lower on the average and quite likely lower in the specific case, but it won't change the decision. There seems to be obvious benefit to having an ARI, and if some plant like Brown's Ferry, as an example, has an ARI already, more power to it.

The regulatory decision is more focused on the end state of a plant having it, and only looking at the value impact, if it could turn the decision around or deflect your desire to go that one more step, in this case, even with a high number -- we know it is somewhat high -- the decision go forward.

MR. EBERSOLE: Would that be true of the other modifications, which are a lot more expensive?

MR. BERNERO: That is where we look hard at down time and things like that. I don't think we get as much on ARI, because we didn't see it as making a difference.

MR. KERR: One of the things you would have to do is get Mr. Ebersole's estimate of how he would fix it. I'll bet he could come up with a baling wire and pliers fix that would work and wouldn't cost much, but they aren't available any more. Baling wire, I found that doesn't even existing any more.

MR. EBERSOLE: You can't even buy it.

MR. KERR: I don't know , farmers do anything.

Mr. Knuth, we have been waiting.

MR. KNUTH: Mr. Page.

MR. KERR: I had your name down, and I made Mr. Page wait. I apologize.

Mr. Page, you are on.

MR. PAGE: You were partly correct.

I am Earl Page, employed by the Detroit Edison Company, but speaking here today on behalf of the utility group on ATWS.

MR. KERR: Do you have a mike? You should.

MR. PAGE: I knew I was too comfortable.

This utility group consists of some 22 members, and represents the nuclear utility industry, the power plants from all four vendors. It was established in 1980, and was established in order to represent this utility industry on the ATWS issue. As you know by now, we have proposed what we feel to be cost-effective features and procedure changes that place ATWS in the category of other low risk accidents without a requirement that they be considered design basis accidents.

The group has developed value impact studies and the accompanying probabilistic risk assessments using, where possible, equipment failure probabilities of the NRC staff, including the staff value per scram failure itself, but the PRA portion of this work as published by SAI was discussed with the subcommittee on October 21, 1981, a little over a year ago. Dr. Burns, formerly of SAI, and the principal author of that report, is with us today should you have any additional questions upon that work.

We also have with us a number of utility group members sitting in the audience here who can aid in answering questions you may have.

Now, I think at this point it may be appropriate to respond briefly to the presentation made by Mr. Bernero just before lunch. First of all, we are indeed glad to have the opportunity to hear these proposals, particularly in the timely fashion before they are even formally endorsed by the task force. Moreover, just a quick consensus, you might say, we agree with a good amount of what was proposed. A significant amount of the overall approach was agreed with.

This is based on the analysis and work done by the utility group over the past several years on this ATWS issue. We do have some concern over certain elements of the proposal. One, for example, or I might say even principally, we feel that operator action in conjunction with the proposed utility fix will have a beneficial effect, and that was not considered by the staff, addressed by the staff, or however you would like to say it, but as soon as we receive this proposal in writing after the endorsement and so forth, we will be arranging pretty quickly for a review by our group and a group meeting to prepare an informal response.

I would like to move on and discuss two specific aspects of the utility group proposal that were not discussed in our last presentation to you one year ago, which will at the same time include the concern I mentioned earlier with regard to Mr. Bernero's presentation.

While the utility group proposal obviously deals both with pressurized water reactors and boiling water reactors, there has been less controversy with the pressurized water reactors. Today's discussion will focus principally on improvements affecting the boiling water reactor ATWS. These are in the area of emergency procedures and specifically deal with the emergency procedure guidelines, EPG's, as they are sometimes called, developed by the BWR owners' groups over the last few years, specifically how they apply to ATWS, that is.

At the time of the original utility study, these EPG's were in the development stage, and very little credit was taken for operator action during an ATWS event. Now, in addition to the discussion on operator action, we would like to present the results of the value impact study that deals with ATWS events for all of the four reactor vendor types, and the effect of operator action included. Leading these discussions are Don Knuth of KNC and Ed Cobb of Boston Edison. Don is a coordinator of our utility group. Ed Cobb has been with this company since 1969, and more recently has served as chairman of the EGP subcommittee of the BWR group.

Don, would you like to start?

MR. KNUTH: Thank you, Earl.

As indicated by Earl Paige, in my portion this afternoon, I would like to be dealing pretty much exclusively with the addition and reanalysis that has been performed by the utility group since the PRA was completed somewhat over a year ago. These deal in the main, as Earl indicated, with the factoring into the BWR of ATWS situation, the factor of intervening operator action. Following the discussion of the taking credit for operator action, I would also like to go over a value impact statement for both the BWR's and the PWR's, and it in many cases does depart from what you heard this morning from Bob Bernero.

As Earl also indicated, the main improvement in the BWR risk analysis was taking advantage of operator actions. At the time of our original study, we had not focused in on the benefits that might be available for corrective actions which would be initiated by an operator. At that time, the emergency procedures guidelines were under development, and they did not at that time directly deal with the ATWS event. The improvements in safety that we believe possible by taking credit for the EPG's or operator actions are shown on this first slide.

As shown, the original base case, which I call the pre-utility proposal, that is, pre-RPT trip, this is going back into antiquity, as Bernero aptly put it. The base case that we started from or the NRC value in NUREG-0460 was 2×10^{-4} as the probability of an ATWS event per year. SAI in its study, which was discussed with you at the meeting one year ago, recalculated the base line, taking credit basically for grouping the transients into high power and lower power events and taking credit for the different frequency of anticipated transients for the first year versus the remaining years of operation.

This reduced basically the probability of unacceptable consequences from two to 1.3×10^{-4}. The original filing had no credit for operator action. It was basically using a 200-degree temperature limit, which basically, looking at the human error probability curves, which were based upon Swain-Gutman consultant from Sandia in a report to the NRC, basically, the human probability error we used for that event was 99 percent of the time he would not do it, or would do it wrong, so basically there was no credit for operator action in the original rule.

MR. KERR: I am sorry. Does it distinguish between not doing it and doing it wrong?

MR. KNUTH: Either way, 99 percent of the time it leads to unacceptable consequences.

MR. KERR: The question I am trying to explore is, it is one thing to not do anything, and you can certainly predict the course of events, but suppose the operator does one among a population of wrong things he can do which might aggravate things. You didn't take that into account?

MR. KNUTH: No, it was basically the time he had to take correct action and whether or not he took correct action was the guideline.

MR. KERR: All right.

MR. KNUTH: In reviewing the work we submitted at that time, we believe that additional credit could be taken for operator action in responding to an ATWS event for the early operating boiling water reactors either having a MARK I or MARK II containment. We believe that additional credit could be taken for pressurization of the containment as the temperatures in the wet well reached 200 and in fact exceeded 200.

We recognized at that time, and still do, that the basic licensing limit is 200 degrees. Since all of the tests and all of the data that has been filed with the NRC in support of a temperature limit are based upon tests, almost all of it at atmospheric pressure, we believe taking credit for the operator actions that we are now using in the EPG's will yield about the same credit. It will end up a probability of about 1.6×10^{-5} versus the original estimate of 1.5×10^{-5} if you use a ten-minute time period, which corresponds to a containment temperature of 285.

What we would like to do today is spend some time with you describing the operator actions to be taken in the control room in response to an ATWS, and as I said, in using the technique or the analysis we are now presenting you today, and we have discussed with the task force, they have asked us a number of questions. You will note that we no longer take credit or are using a 285-degree temperature limit. We are using for purposes of this analysis 200 degrees.

The key to understanding the EPG's, and it was discussed at some length this morning, is the general understanding of how the reactor power level in a boiling water reactor responds to the control of the water level. One of the key actions of the operator, in addition to initiating the standby liquid control system, is in controlling the water level. Intentionally lowering water level from the normal position to near the top of the active fuel will reduce the natural circulation occurring, since the pumps have already tripped.

He will increase the voids in the core, and correspondingly can reduce power by about a factor of three. This lower power generation causes less steam to be available for suppression pool heatup and allows more time for an operator to terminate the transient.

At this time, it might be worthwhile to have Mr. Cobb of Boston Edison come up -- he has been a supervisor at the Pilgrim site -- and have him walk through two responses that an operator would take to two separate ATWS events, that of the turbine trip transient and the more demanding transient of the MSIV closure.

MR. LIPINSKI: Before you take that off, could I ask a question? You have a number, 4.1 x 10^{-5th}. If I multiply that by the 4.4.*, I get to the 1.6 x 10^{-5th}, right? And the .4 corresponds with the number we saw earlier on the NRC plot for high risk at ten minutes.

MR. KNUTH: Could be. That is not how it was arrived at. The probability that an operator in ten minutes in our calculation would take correct action is, he would take correct action 16 percent of the time. No, wait. He would take correct action 84 percent. He would take incorrect action 16 percent of the time. It is not multiplying by a factor of four. It is actually entering into the -- and perhaps Ed Burns of SAI would like to respond to it, but it actually enters into the PRA analysis, but the human factor element is .16.

MR. LIPINSKI: So again we have to see the entire tree to find out what the task for operator contribution is versus the others.

MR. KERR: Mr. Page, did you have a comment?

MR. PAGE: I wanted to make a brief qualification. The .84 percent or 84 percent success for that response is for the turbine driven bypass only. It is not for the MSIV closure event, which is a more demanding event with a much lower success rate.

MR. LIPINSKI: While we are still on that subject, then, if you use a number of .84 for operator success, that would not correspond with the NRC high stress curve. You are using a number less than high stress.

MR. KNUTH: That is correct. It is an average. If you would like, we could show you the average we use. I believe the chart Mr. Bernero showed you showed you what the utility group did. It was a mix, a balance between high stress where the operator basically does not have procedures to follow. It is an unexpected event. And the other one is a planned event, which is trained for, and we took basically midground between the two, because it was our contention that operators should in fact be trained and should be qualified to respond to an ATWS event, have procedures to tell him what to do, and he is trained to do that.

So, we did not take the lower curve, but we didn't take the upper curve either. It is a mix between the two.

MR. LIPINSKI: The question is, how applicable are these curves when you consider the decision he has to make as to whether he manually injects that poison and endures a $25,000 to $50,000 cleanup cost.

MR. KNUTH: I would like to let Mr. Cobb go through that. I am sure he will answer those questions and allay any concerns you may have in that regard.

MR. KERR: Are you really?

MR. KNUTH: Yes. The first positive answer, yes.

MR. COBB: When the new emergency operating procedures developed from the emergency procedure guidelines put into place in the plants, they require operators to react to symptoms and to know what the symptoms are rather than to know what event they are in, and the plants' symptoms are entry to a direct execution of the emergency procedures.

Now, the symptoms are pressure above a certain point, level below a certain point, and power, which we will talk about today, above a certain point. These are all entry conditions into reactor pressure vessel control guidelines. At the same time, we have entry conditions into containment control which are suppression pool level, suppression pool temperature, dry well pressure, and dry well temperature, and these parameters are all monitored concurrently as any event progresses, and the operator takes action as appropriate.

Today I am going to make a presentation that will illustrate how an operator in a typical nuclear plant will react to and control two mechanistic events using procedures developed from a new symptom based emergency procedure guideline. These two events are turbine trip from 100 percent power which results in an ATWS, and MSIV closure from 100 percent power also resulting in an ATWS.

Let's start with the first event, under plant conditions prior to the transient of 100 percent power and a suppression pool temperature just below the RCO, which is typically 90 degrees Fahrenheit. Now, at the onset let me put this slide up. This is a control room with which I am fairly familiar, from which I will say how the operator reaction -- where he has to go in this control room to make his decisions and do his actions.

For this, I will take the place of this man right here, who is the operating supervisor. There is also an operator stationed here all the time. Your watch engineer may or may not be in his office. He may be in the plant. There are two other reactor operators available. However, they could be out in the plant doing some other work. So, at the onset, we are just going to have this man and this man in the control room (indicating).

Now, at the onset of the transient is the turbine trip, which would be acknowledged by an annunciator on this board here, and closure of the turbine stop valves, which are right here. This would be followed by a reactor scram from channel A and B, and that is located on the back board here on 905. Bypass valves would open. They are located here. Their indication is here. And the leak valves would open. The indication of the relief valves being open is on this panel, which can be easily seen from this man and this man over here.

Okay, this pressure transient would cause the RPT, the RPT API trip, which would run reactor power back to approximately 40 percent. When that happens, the scram air header should be bled off. Control rods should go in, but to keep the scenario going, we will assume that that fails and the control rods stay on.

MR. LIPINSKI: What is the operator's indication the control rods stay up? He has position indicator dials in front of him. In what form are they? Digital?

MR. COBB: On the back board right here, they are all lit. All of the rods that fall out are lit red, I believe, and all of the rods that fall in are lit green.

MR. LIPINSKI: Is there any kind of a common mode failure that would keep those red lights on even though the rods went in?

MR. COBB: Even if you had a common mode failure, you have your APRM's here, which would be indicating power.

MR. LIPINSKI: I am looking for anomalies the operator will have to fight with. You can run through your normal sequence, but there will also be anomalous conditions.

MR. KERR: Why don't we let him go through this first?

MR. LIPINSKI: All right.

MR. WARD: One question, Ed, while you are interrupted. Is the operator at the board an SRO or an RO?

MR. COBB: This man right here is an RO. This man here is an SRO, typically. This man could be an SRO, but typically he is an RO. Okay?

Now, power as indicated on the APRM's is greater than the APRM downscale. The scram should have occurred, and this is an entry condition for RPV control, so we are right into it. The pressure due to the fact that you have a relief valve opened and one partially opened trying to control the pressure, the pressure could be oscillated. Now, the operator would move to get that pressure under control as per the RPV pressure control guideline.

I would be here (indicating). My first move would be to sound the operator recall siren, which would get any operators out in the plant and the watch engineer if he happened to be in the plant back in the control room. I would notice immediately --

MR. LIPINSKI: How many minutes would that take?

MR. COBB: Typically --

MR. LIPINSKI: Yes?

MR. COBB: -- well, let's put him at the far reaches of the place. Let's put them out in the screen house. He could be in the control room probably in a minute, a minute and a half, and that would be about the farthest he could be away.

MR. COBB: Where was I? I would notice immediately by standing at the back board and noticing the APRM's that the control rods are not in, and I would verify that the operator here has placed the mode switch, which is located here, in shutdown. Also at that time, I would verify that the MSIV's, located right here, are indicating open.

I would then verify that the recirc pumps -- their indication is right here -- I would verify they are tripped. If they hadn't tripped, I would have the operator trip them either by the controls here or pushing the RPT pushbuttons that are right here.

At this time I would have one of the RO's out in the station, along with an AO, attempt alternate actions to get the control rods inserted. That would be under the direction of the control room.

However, to keep the scenario going we will assume that all of that fails.

MR. EBERSOLE: May I ask a question?

MR. COBB: Sure.

MR. EBERSOLE: You didn't mention whether or not bypass was taken care of for steam flow. You have not closed the MSIV's and I don't know what your percent bypass is, but if it's big enough, fine, you are in high cotton.

MR. COBB: I am talking from a plant I am familiar with and operated in. Our bypass valves up here are good for 25 percent.

MR. EBERSOLE: That's not enough.

MR. COBB: 25 percent would be going out here and the other would be going out the relief valves.

MR. EBERSOLE: All right.

MR. COBB: All right. We are trying to get the rods in. The next thing we would want to look at would be the suppression pool temperature, located on this board here (Indicating). And I would realize that that was increasing, that I had a relief valve, one open and one cycling. I would know I couldn't get shut down before the suppression pool temperature before got to 110 degrees.

Therefore, I would tell the operator to operate the standby liquid control system located here. By this time, this RO that I called for originally from here would be in the control room and I would have him over here, putting in suppression pool cooling to try to get some of that suppression pool temperature down.

MR. WARD: Ed, could I ask you a question. You said you would know you couldn't keep the suppression pool from getting up to 110 degrees. How would you know that? Did you make a calculation in your head or what?

MR. COBB: I started at just below the LCO. I started at somewhere around 90 degrees. Now, when I look at it I will probably see a trending up. I know I have one relief valve open right now. I have another one that is cycling. There is no way that I could think of that I could stop that before it got to 110 degrees. Even if I got all four of these in and it was in the middle of February and the bay was 30 degrees, I probably couldn't stop it.

So knowing that, that is a key to start the standby liquid control.

MR. EBERSOLE: It sounded like that was you focal point for identification of reaction. Is that right? I know you had these other preceding --

MR. COBB: You are above three percent, your suppression pool is above 110, your ADS valve is open, okay. Those are all actions that key you to start the standby liquid control and to lower the water level.

This operator also, when he starts the standby liquid control system, would inhibit the ADS system. His next move would be to make sure that the cleanup system was isolated, and I would have him immediately start to lower the water level by terminating or preventing all injection into the RPV except from the boron injection system or the CRD system.

All right. The operator would continue to lower the water level until such time as he got both these ADS valves closed, and all of this power would not be going out through the bypass valve into the condenser, and that is what we want.

MR. DAVIS: Excuse me. Wouldn't lowering the water level in the vessel close the MSIV's?

MR. COBB: It might and it might not, depending upon where the set point is. If it does, if it did at Pilgrim, there would be a procedure in place once the guidelines are out or approved that would give the operator direction on how to bypass that low level interlock to keep the MSIV's open.

MR. EBERSOLE: Are you headed for the 285 degree condition?

MR. COBB: No, not under this. We lower the water level and get the ADS valves closed and all the power is going up the bypass valve. Now, the operator, myself, would monitor all plant conditions while the boron was going in and the power of the reactor was going down.

The plant now as far as we are concerned is in a stable condition and it's time to notify the NRC and station personnel that we have had a transient, and also enter the emergency plan as necessary. When power level drops below three percent, we would have the operator put the SRM, the RRM and the SRM's, drive them in to keep monitoring the power level.

I would then determine that enough boron had been injected, and that indication of the tank level is right here, to maintain the reactor shut down. We could then raise the water level to the normal water level and into the scram procedure which leads us to the shutdown procedure, keep the standby liquid control system in service until such time as the tank is empty.

And this concludes the transient with enough standby liquid control in the vessel to maintain it in a cold shutdown condition.

MR. EBERSOLE: When do you start cooling the torus down?

MR. COBB: The guy already got this in.

MR. KNUTH: As soon as we go through the procedure aspect of it, I will go through another slide that shows the temperature transient that the suppression pool takes as a function of time.

MR. EBERSOLE: When did you start the RHR pumps?

MR. COBB: When?

MR. EBERSOLE: Yes.

MR. COBB: I realized I was in an entry condition to containment control, and once I was in that entry condition to containment control, as soon as I had a man available I am directed to put the RHR into suppression pool.

MR. EBERSOLE: The primary system pressure is still high, right?

MR. COBB: Oh, yes.

MR. EBERSOLE: Are you going to start running it down now?

MR. COBB: No. This transient now is shut down. The boron is in. It is a shutdown condition. It is time to get it into cold shutdown and do what we have to do.

MR. EBERSOLE: How are you going to get it into cold shutdown?

MR. COBB: There's enough boron in the tank to bring it to cold shutdown and maintain it in cold shutdown, even if none of the rods move.

MR. EBERSOLE: I will tell you what I was waiting for. I was waiting for you to open up the RHR system and flush all the boron out into the suppression pool. But you didn't do it.

MR. COBB: I shoot myself in the foot, so to say.

MR. WARD: You say you check to see that enough boron is in. Was that by seeing how much is left in the surge tank, or how?

MR. COBB: Typically, the numbers we have in the emergency procedure guidelines are for our Hatch plant. For my plant I have to get so many tons of boron in there which is equal to hot shutdown and so many tons equal to cold shutdown. Well, that translates to a certain level on the tank.

MR. WARD: On the boron storage tank.

MR. COBB: That's right, and it would be in my procedure, because the tank is at this level.

MR. WARD: So what isn't left in there is in the reactor.

MR. COBB: (Nods affirmatively.)

MR. WARD: All right.

MR. EBERSOLE: Is the plant you've got -- well, you are going to evaporate cool on down to low temperatures through the condenser. You are cooling by evaporation into the condenser?

MR. COBB: Yes.

MR. EBERSOLE: All right. You can get down quite low that way, right?

MR. COBB: Yes.

MR. EBERSOLE: You are working into a vacuum into condenser.

MR. COBB: We can get enough boron in to maintain cold shutdown. We have already got the calculation of how many tons of boron we need, including the diameter of the pipes, the volume of the pipes, that take care of shutdown cooling.

MR. EBERSOLE: Life will be a little different when we close the MSIV's on the next one.

MR. COBB: Everything in a BWR gets a little bit worse when the MSIV's go.

MR. EBERSOLE: Does that make you want to leave those valves open if you can?

MR. COBB: If I can, absolutely.

MR. EBERSOLE: Wouldn't you like to see a time delay, some inhibit on them so that you didn't close them unless you lost vacuum?

MR. COBB: Oh, absolutely.

MR. EBERSOLE: But you don't have it.

MR. COBB: Well, we don't have it yet.

MR. EBERSOLE: Okay.

MR. COBB: Continuing with the second event, and this is basically almost identical, so please bear with me. Plant conditions for the transient are exactly the same as for the other transient: 100 percent power, suppression pool --

MR. KERR: Excuse me. Before you start the second one, do you have some estimate of the time it would take to go through the procedure from the time you observe until you have the boron in that you need to go to hot shutdown?

MR. COBB: Yes. When I first wrote this up I had times I estimated, okay. I estimated I had the ADS valves shut, all of the power going out through the bypass valves, and the plant stable, ready to call the NRC and everyone else I had to call within six minutes.

MR. KERR: Okay.

MR. LIPINSKI: In that procedure are there some that are immediate actions that have to be memorized and others you can pull the procedure out of the file?

MR. KERR: There are no immediate actions in the emergency guidelines. The only thing the operator would have to memorize are the entry conditions, so that he knows he's indeed into an emergency situation.

MR. LIPINSKI: Do you mean he has sufficient time to go to the bookcase and pull out the station procedure?

MR. COBB: Yes. Well, no. Well, a well-trained operator can get through the first couple of steps, but they are not immediate action steps. And then he will have the procedure out. This guy here (Indicating) is the guy who will probably pull the procedure out while the operator is doing the action.

MR. KNUTH: To answer your question, on my slide I will show you what the effect is if he waits for ten minutes before he enters it.

MR. LIPINSKI: But in a normal procedure, from the ones I have seen, if there's anything that calls for reactor trip the first thing they are supposed to do is observe whether the rods went in or not, and if they haven't they hit the scram button to see if they can manually insert rods. That is called an immediate reaction on most plant procedures.

MR. COBB: The hitting of the scram button is taken. As I said, when you enter one of these emergency procedures, you not only enter the one that will take care of ATWS; you enter the level control, scram, pressure control, and power control.

Over in the level control procedure is a step that says, if the scram hasn't occurred hit the scram button. It's in there for a reason. Over here, you put the mode switch into shutdown, and that is strictly to give you another electrical input into that scram.

MR. LIPINSKI: The thing I am trying to differentiate, if we take the operators to do their examinations in terms of the things they have to commit to memory because time is not available to them to go consult the bookcase, where they have to observe the event and take an immediate action based upon their memorized response.

MR. COBB: Would you like to respond to that?

MR. BOUGHMAN: Gary Boughman.

I would like to respond to that question on immediate action. It is a little tough for Ed to place himself in that position because his plant does not yet have EDG-based procedures. At Susquehanna we have these procedures. Our ATWS procedures that exist today, we do have immediate actions of trying to get the scram. If you realize you have a valid scram signal and the rods haven't gone in, you hit the scram buttons, you place the mode switch in shutdown, and then you grab the procedure, which gives you guidance on when to initiate standby liquid control.

MR. LIPINSKI: Thank you.

MR. KERR: Thank you, sir.

MR. LEE: One more.

MR. KERR: A second question. I was going to ask, in your comments on turning on the key that triggers SLC, you said you would tell the operator to do this, I think. Is that -- what, normally he wouldn't do it until you told him to do it?

MR. COBB: Oh, no. He's under a procedure to do it. I think what you are saying is, if I went from here and dropped dead right here, he would still hit the slick.

MR. KERR: No. I am looking at a situation in which you don't drop dead, which I think is more likely. Is he going to wait for you to tell him?

MR. COBB: He has a procedure.

MR. KERR: Suppose you see he is about to do it and you decide it's not the thing to do and you yell at him not to do it. What does he do?

MR. COBB: He has a procedure that has been approved by the PORC Committee, which is the safety committee in the station. It has been approved for use. That procedure says, if you get X, Y and Z, you hit boron, and he's going to do it.

MR. EBERSOLE: Is the borating switch a double switch? Does he have to energize two handles or break a seal? Are there inhibits on it?

MR. COBB: No. It's a key lock switch, and the key is hanging in this back board right there. It says "Standby Liquid Control Key" there.

MR. EBERSOLE: Is it always there?

MR. COBB: Yes, sir.

MR. KERR: Mr. Lee?

MR. LEE: How accurately can you determine the water level, especially as it is brought down to the top of the active fuel element?

MR. COBB: I would probably have to refer that question to people who have analyzed it. I have never had the water level down in an actual plant during operation.

MR. KERR: Could the gentleman from Susquehanna assist us here? Did you understand the question Mr. Lee was asking?

MR. BOUGHMAN: How accurate is the water level?

MR. KERR: How accurately can you determine water level when the water level is near the top of the core? Within two inches, six inches, a foot?

MR. BOUGHMAN: We are aware there are some inaccuracies in the fuel zone indicators, in that they are full calibrated. But as I said before, you have a backup means of determining the water level. You can use the fuel zone indicator for guidance, you can use the indicator reactor power for guidance, as you have a water level somewhere near the top of the fuel.

MR. KERR: So you can determine within about six feet?

MR. BOUGHMAN: Oh, I would say you could determine closer than that.

MR. KERR: Two feet?

MR. BOUGHMAN: I would say two feet would be a good number. I have run this particular procedure on the simulator at Susquehanna because I had some doubts about that particular item, and you really don't have any problem throttling the water flow to control the level if you go by the power indication.

MR. DAVIS: But won't both the power and water level be oscillating under these conditions, or couldn't they be?

MR. BOUGHMAN: They may oscillate slightly until you get the SRV's closed. Once you have the power down to the point where they are closed, which is what you are aiming for when you lower water level to you get those SRV's closed, the power pretty well levels out and starts to decrease.

MR. DAVIS: I have seen quite a few ATWS calculations that show rather large oscillations. I don't know if they are real or not.

MR. COBB: Could I direct myself to that question? One of the things in the EPG's is pressure control. It direct the operator to get pressure under control, because that is a contributing factor on being able to tell where the water level is and where the power is. So the first step is to get the pressure under control.

MR. KERR: Does that answer your question, Mr. Davis?

MR. DAVIS: (Nods affirmatively.)

MR. KERR: You are convinced he can get the pressure under control?

MR. DAVIS: I wouldn't say that, but it answers my question.

MR. KERR: Mr. Lee?

MR. LEE: Can I turn my earlier question around a little bit, then? How accurately do you have to know the water level in order that the whole maneuver of bringing down the water level can become effective?

MR. KNUTH: Let me answer that. You are getting into the analysis portion.

MR. LEE: I can wait if you are going to cover that.

MR. EBERSOLE: Question: Isn't there an interrelationship between water level and power level, such that the higher the power, a given cold water level will appear to be a higher level due to the average height being higher? In short, if you raise power from the fixed level indication doesn't level tend to go up?

They are interdependent.

MR. KERR: If you understand the question, if you do, answer it. I don't understand it. Maybe you do.

MR. EBERSOLE: Water level and power are interdependent parameters, so that if you alter power level at a fixed cold level you will have an apparent higher level with the same water inventory.

MR. KERR: Would you please come to the microphone. We don't want your words to get lost.

MR. EBERSOLE: What it leads to is instability.

MR. KERR: Do you know the answer to your question, Mr. Ebersole? Is this a didactic question?

(Laughter.)

MR. EBERSOLE: I want to know. I think there is an interrelationship. As the power goes up, the average level of the water rises.

MR. ROGERS: Taggert Rogers, General Electric Company. We have done a fair amount of support work for the owners group on the development of emergency procedure guidelines.

As the void content in the reactor, in the core region, increases the two-phase water level does increase. What is important to remember here is the water level instrumentation for all except the BWR-2's is an indication of water level in the downcomer annulus outside the shroud, and the void in that region doesn't change. That is essentially a very low void region. An increase in power or an increase in void in the core region will not produce an increase in the water level in the downcomer region.

MR. EBERSOLE: It will stay flat?

MR. ROGERS: Pretty flat. You will see a little bubble due to the change in flow resistance, because you increase the void in the core, you increase the thermal driving head for whatever natural circulation is present, which gives you a little bit of flow resistance, which will produce a slightly higher hydrostatic head out in the downcomer region.

MR. EBERSOLE: The fact that you don't measure the water level over the core was, of course, the problem we get into -- I forgot which reactor it was where we got the expected result. I thought you were in the process of fixing that problem.

MR. ROGERS: It is a problem, yes and no. The fact that the operator controls level of water in the downcomer is actually a blessing in this particular case, since if he controls the top of the active fuel for the highly voided ATWS condition, he guarantees himself three, four, or five feet of water over the core inside the shroud region.

What this means is, if he misjudges control of water level, if his instruments are off by several feet, as we were discussing before, if he loses control and subsequently restores it, the water level in the core region is very unlikely to get below the top of the active fuel. And even if it does, the amount of voiding and boiling occurring in the core at this time carries a very large amount of steam up through the core, such that we believe from best estimate calculations that we have done that we could uncover a substantial portion of the core, the upper portion of the core, without doing any fuel damage for a sustained period of time.

MR. EBERSOLE: Thank you.

MR. KERR: Mr. Epler?

MR. EPLER: I have an interest in this key that hangs by the key switch. Considering the vulnerable nature of that switch, how frequently and how completely is a test performed that shows that is the right key and the switch actually is capable of inserting boron?

MR. COBB: Are you asking if the key is tested to see that it fits the switch?

MR. EPLER: Yes.

MR. COBB: On a frequent basis?

MR. EPLER: Yes, I would like to know how frequently you are assured this works.

MR. COBB: I just don't really know whether it's tested, whether the key will fit the switch. I don't know of any surveillance we do to do that. We test the rest of the system. We test the system that it will run. We know there's continuity between the switch and the squib valves because there are lights and a meter out back that tells us continuity.

But to say that that key fits that switch --

MR. EPLER: It would be a good idea.

MR. COBB: Who? I mean, I can't for the life of me see who would touch that key.

MR. KERR: The answer to your question is, in his plant he doesn't test it.

MR. COBB: Not that I know of, not that I am aware of.

MR. KERR: You would probably know it.

Mr. Lee?

MR. LEE: How soon can you somehow get an actual measure of the boron concentration in the reactor coolant system, if at all?

MR. COBB: We can take that out through the normal reactor sample.

MR. LEE: How long would it take?

MR. COBB: To run a test?

MR. LEE: No. After you have observed turbine trip, how long would it take before you can get to verify it if boron has been inserted at all?

MR. COBB: By six minutes I am in a stable condition. I think it is somewhere in or around a half an hour. I think that is the figure used, around half an hour to get enough boron in to be in hot shutdown. At that time you have to get the chemistry people to get the boron, to get the water, to take it up to the lab, to sample it.

I don't really have a feel for what kind of a test they have to go through or how long that would take.

MR. LEE: Sampling is not included in the present procedure, I understand from your remark?

MR. COBB: It is not an operator's function. I am speaking from an operator's standpoint.

MR. LEE: For the emergency condition you are going through, it has not been included?

MR. COBB: My emergency procedures will say that the tank level at a certain point equals X pounds of boron in a reactor. But to actually get a sample and to test that that is in there, the test on that is as you raise the water level. Once you start to raise the water level, if it's not there you are going to see that power.

MR. LEE: Power is still being monitored through APRM's?

MR. COBB: Until you are down to the three percent down scale, which takes you off the APRM's. And I had a little scenario in there later on in the thing where I had the SRM's and IRM's inserted so he could monitor power as he was going down below his APRM's. So, yes, he has all of his nuclear instrumentation there to monitor power, and if he now starts to raise water level and the boron is not in there the power is going to come right up as the water level comes up, the same way as it went down as the water level went down.

Boron injection is not terminated until the tank is empty.

MR. LEE: If you do see some kind of oscillation of water level and power level, which I have seen some of the BWR ATWS analysis, what would you do?

MR. COBB: I didn't follow the question.

MR. KERR: Did you understand the question?

MR. LEE: Apparently not.

In several ATWS analyses that I have seen in boiling water reactors, one could conceivably go through considerable oscillations, power level, void content, as well as the water level.

MR. LIPINSKI: This is previously referred to as chugging.

MR. LEE: Chugging.

MR. PAGE: May I address that? I am speaking partly for GE people and a little bit for the operating group.

I think the newest analysis on the ATWS condition, even with the turbine trip bypass most of those oscillations went away due to an improved model taking into account the more accurate quenching effects of the HPCI and what-not. They didn't even use EPG. This was the automatic boron injection and so forth. Those oscillations -- if you have seen the report I am thinking of, in the GE report dealing with the 3A fix, the automatic injection of boron and so forth, a subsequent analysis using an improved quenching model for HPCI.

In that case the oscillations went away. If this is something else you are referring to, I am not aware of that.

MR. LEE: I am referring to the same thing. And what you are telling me is, based upon the current state of the art, you don't think there would be oscillations?

MR. PAGE: That's my understanding. That is a communication I have received in various ways. I have not done the analysis. Are there GE people who could confirm or deny what I am saying.

MR. FLEISCHER: Confirmed.

MR. KERR: Would you please come to the mike.

MR. FLEISCHER: My name is Larry Fleischer from General Electric. We have done some analyses with our computer codes comparing to the plant test data we obtained from the Vermont Yankee test on stability, and we have applied that information and verified our codes so that we can predict what happened at the Vermont Yankee test. We have applied it to both the EPG analyses and other ATWS analyses, and we now predict stable operation.

MR. KERR: Thank you.

MR. LEE: May I follow up a little bit?

MR. KERR: Surely.

MR. LEE: When you say "stable operation," do we see that the power can be decreased to a certain stable level there, or do we have to contend still with some amount of oscillation? I think you do have in BWR's inherent oscillations, the chugging phenomenon or whatever you want to call it.

MR. FLEISCHER: The only power oscillations we see are associated with the SRV valves opening and closing, which are power changes and not really oscillations. There is no continual up and down motion other than associated with pressure changes in the vessel.

MR. KERR: Mr. Davis?

MR. DAVIS: The operator controls flow by controlling main feedwater. Is that right?

MR. COBB: That is the best water you've got in the house.

MR. DAVIS: If he gets the water level too low, won't that automatically start the RCIC?

MR. COBB: It sure will.

MR. DAVIS: And he has to control that also?

MR. COBB: No, it said right at the top that you prevent or inhibit --

MR. DAVIS: Oh, you inhibit RCIC?

MR. COBB: There are ways of doing that.

MR. EBERSOLE: Would you have a curiosity --

MR. KERR: Are you finished, Mr. Davis?

MR. DAVIS: Yes.

MR. KERR: Go ahead.

MR. EBERSOLE: Would you have a curiosity as to whether the key hanging by that switch fits and will work when you go back to the panel? I believe you will, won't you? You will stick it in the switch and you will turn it. When you turn it, is there a risk you will inject boron?

MR. COBB: You have got to put the key in the switch. You turn the key and then you turn the switch.

MR. EBERSOLE: But when you turn many keys, once it gets to turning, it turns the switch, too.

MR. COBB: This is basically the same type of switch as the mode switch, and it does not turn, and in fact you really have to swing it.

MR. EBERSOLE: You really have to put the muscle to it.

MR. COBB: Turning the key is nothing. Turning it to arm it.--

MR. EBERSOLE: Then you can put the key in it and unlock it without being apprehensive?

MR. COBB: Sure.

MR. EBERSOLE: But you never do that, right?

MR. COBB: I didn't say we never did.

MR. KERR: He just said he never did it.

Yes, sir?

MR. BOUGHMAN: Gary Boughman.

That key switch and that whole circuit is required to be tested every 18 months by technical specifications, and during that test, you do actually detonate one of the screw valves to determine its operability. At all other times, you have the continuity monitor, but the actual putting of the key in the switch and turning it is required every 18 months.

MR. EBERSOLE: There was a reactor out at

Idaho Falls which went through its entire operating history with the squibb valve short-circuited.

MR. EPLER: With shipping bolts.

MR. EBERSOLE: How do you know yours aren't short-circuited?

MR. BOUGHMAN: We will be testing them every 18 months.

MR. EBERSOLE: I will have to digest that.

MR. KERR: There is a slight time delay, Mr. Ebersole.

Other questions?

(No response.)

MR. KERR: Thank you, sir. Will you please continue your interrupted presentation?

MR. COBB: MSIV closure, and basically a lot of the lead-in stuff that I did on EPG's I will not go through again. This is basically almost the same scenario, so a lot of it is a repeat. The second event, same parameters to start, we have 100 percent power, and the suppression pool temperature is just below the LCR. MSIV closure would be verified by the annunciator on 905, which is here, and by observing that these steam isolation valves are closed.

This would immediately result in a reactor scram from both channel A and B. Our relief valves would open as indicated down here. You would have all four relief valves opened and possible safety valves would open.

This pressure transient would result in the RPTIA trip which would cause power to drop to approximately 40 percent. Again, as I stated before, when the scram valve A header is off, the rods should go in, but we will assume they don't so we can continue with the transient. And again, I will take the place of this man right here (indicating).

Again, we noticed immediately the scram had not occurred, because the scram annunciators are lit. As indicated on the back board here, the rods are still out, and the MSIV's are reading approximately 40 percent. It would also be observed at this time the MSIV's are closed. Again, this is an entry condition into PRV control, so we would be into the emergency procedures controlling level, trying to control level, pressure, and power.

MR. KERR: Mr. Lee?

MR. LEE: I can wait. I am sorry.

MR. COBB: To verify the operator had placed the mode switch in shutdown, I would have the operator verify or I would verify that the recirc switches are tripped. If they weren't tripped, he would trip them by pressing the RPT's or tripping the breakers. At this time again I would have an RO assisted by an AO go out in the plant and take alternate actions to get the rods inserted, and again, we will assume that everything they do is okay.

You would realize you had four temperature valves open. Pressure is releasing. You couldn't get to entire shutdown before reaching a temperature of 110 degrees F. in the suppression pool. So the operator, the other RO, when he showed up in the control room, I would have him working here, putting the RHR in the suppression pool cooling, and he would also be monitoring all my containment parameters, while this man here would be monitoring the reactor itself.

At this time, the operator would inject the boron and permit automatic initiation of ADS, and he would verify the cleanup system had isolated.

MR. WARD: Up to this point, you haven't done anything different than you did for the turbine trip.

MR. COBB: The same. The same. Other actions that would be taking place at the same time. This operator here, that I have working here, would be placing the standby gas treatment system in service as per containment control for pressure. He would also be verifying and placing the dry well cooling system in service as necessary for a containment control for the dry well. And again, I say, he already has suppression pool cooling, and he is the man who would be monitoring the containment parameters.

After he injected the boron, he would start lowering water level by terminating and preventing all injection into the reactor outside of the boron injection system, and the CIB. He would continue lowering water level in this scenario until he reached the top of the active fuel.

MR. EBERSOLE: You never did say much, I think, about his anxiously watching for the start of the HCPI and starting pump to keep it going, but he would do that, wouldn't he? The feedwater system is blocked off now.

MR. COBB: He doesn't want that. That is the last thing in the world he wants, is water.

MR. EBERSOLE: He doesn't want any high pressure core injection yet?

MR. COBB: He wants to get the water down to the top of the active fuel.

MR. EBERSOLE: Does he encounter the level at which it is automatically turned on and does he inhibit it at that point?

MR. COBB: He inhibits it okay. And how he inhibits it, he has got a man working right here. He might say, lower the water level, inhibit HPCI. Don't let RCIC come on.

MR. EBERSOLE: In the meantime, he is coming down to a level that would have initiated HPCI. How much time will it be before he gets there? Is it very long?

MR. KNUTH: It is about a minute and a half, I think.

MR. EBERSOLE: So he has got a minute and a half, and then it is going to start?

MR. KNUTH: If it starts, he has to shut it off.

MR. EBERSOLE: He has to stop it, and HRH will have already started. I mean, the RCIC. Because it starts a bit higher, doesn't it?

MR. COBB: No, the same place for this control, this scenario.

MR. EBERSOLE: So he is going to stop then. That is contradictory to the usual safety maneuver. He has got to contradict the usual safety procedures at this point.

MR. COBB: Yes, but he is going to have these procedures, and he is going to be trained in these procedures, and this is a safe direction for him to go to conclude this scenario for this proceeding.

MR. EBERSOLE: But in essence, he is going to cut off the emergency feedwater pumps, which is RCIC, and HPCI, and then he is going to turn them on again. Is that right?

MR. KNUTH: I will show you some curves in here, if he doesn't do it like up to ten minutes, what happens to the level of power, temperature, and so forth.

MR. EBERSOLE: All right.

MR. COBB: If he had his what he would rather do, an operator is well versed in the operation of the condensate system and the feedwater system. He uses it every day. He knows it. And if he had his way, that he was going to control water level, he sure wouldn't control it with HPCI or RCIC unless he absolutely had to. He would control it with feedwater.

MR. EBERSOLE: But now he can't because the main steam water isolation valves are closed, so you don't have any feedwater.

MR. COBB: Not in this pump.

MR. EBERSOLE: Why? You have electric pumps?

MR. COBB: Yes.

MR. EBERSOLE: That is not an ordinary plant you have. That is a very unusual plant.

MR. COBB: Well, the other plants, when the MSIV's are closed, then he can take the HPCI and by controlling the injection flow on the back board, he can control the level.

MR. EBERSOLE: But you are somewhat better off with electric pumps. The MSIV didn't bother you.

MR. COBB: Loss of off-site power makes us worse, so --

MR. EBERSOLE: Okay.

MR. KERR: Mr. Lee?

MR. LEE: I believe I am following up a question Professor Kerr raised earlier, perhaps this morning, which is related to the fact that we have considered the operator not taking the proper action in the proper time, but what if the operator takes the wrong action, although perhaps in the proper time, an example of which could be the operator turning on the high pressure coolant system instead of throttling it.

MR. COBB: This is the problem you can get into, and I am trying to take two mechanistic events and tell you on these events how the emergency procedures control them, and the emergency procedures are symptom-oriented. As you come down through the emergency procedures, there are checks and balances so that even if you miss a point, you get it a little further down, but I don't have the time to go through how do you get yourself through all of these emergency procedures and how they check and balance as you are coming through.

MR. LEE: But these will be all covered in your emergency procedure guide? Is that what you are saying?

MR. COBB: No. I am talking about the new emergency procedure guidelines.

MR. LEE: But what we are trying to have is a guide or policy that will bring the reactor down safely to cold shutdown conditions no matter how, right?

MR. COBB: That is what we will have.

MR. LEE: Then you have to account for the fact that the operator can make errors in the wrong direction, not just in not doing what he is supposed to do.

MR. COBB: Absolutely. I agree.

MR. LEE: Is it a part of your emergency procedure guide?

MR. COBB: In the emergency procedure guidelines, if he makes a mistake, if he starts down the wrong trail in the emergency procedure guideline, he can only get so far and he will get caught, and he has got to go back, and they back it up, but like I said, I don't have the time to go through the whole emergency procedure guidelines to show you how it works.

MR. KERR: Mr. Lee just wants reassurance that he will recognize he has made a mistake and can reverse it.

MR. COBB: He sure will.

MR. KERR: You are convinced he will and can?

MR. COBB: He will. He will recognize the mistake and rectify the mistake.

MR. KERR: I think Mr. Ebersole -- Were you just scratching your head, or did you have a question?

MR. EBERSOLE: No, I am still scratching my head, but I don't know what to say, so go on.

MR. LIPINSKI: You have outlined your procedure. Hopefully the operators will never see this incident in an actual reactor in this country. How often do they see it on a simulator?

MR. COBB: Right now I can't speak for every plant in the country.

MR. LIPINSKI: Well, in your plant.

MR. COBB: But we go to simulator once a year, and we work out emergency procedures once a year.

MR. LIPINSKI: They go through all the procedures on the simulator, or only selected ones, once a year?

MR. COBB: I believe they go through all of the emergency procedures.

MR. LIPINSKI: So once a year they will review the ATWS scenario?

MR. COBB: They will see this along with whatever training picks up, and there is training that has to go on on emergency procedures, and our training man here from Susquehanna may enlighten us.

MR. BOUGHMAN: We did extensive training of the operators on our simulator on emergency procedure guidelines with the exception of this new ATWS guideline which was not in existence at the time. The course we put together lasted an entire week of simulator training, and we went through the pr edures exhaustively. I would expect that once this is implemented, it will ge he same treatment, and it will become a part of the normal program for the operators.

MR. KERR: Thank you.

Are there other questions?

MR. LEE: Where does the watch engineer come into your picture?

MR. COBB: Basically, what I am trying to do is show that a supervisor here (indicating), an operator here (indicating), and an operator here (indicating) can handle this transient, and this watch engineer who is in charge (indicating) is the supervisor. When he comes into the control room, if time permits I would brief him on where I am and what I am doing. Other than that, he would come into the control room and he would be standing back watching what is going on, but I am trying to show with a minimum number of people how we can control this transient.

MR. KERR: Where is the shift technical advisor in all of this, or do you have a shift technical advisor?

MR. COBB: Yes, we have him, but the shift technical advisor, when he heard the operator recall, would come to the control room. He has to be within ten minutes of the control room.

MR. KERR: But does he have any part in this procedure, or does he just watch?

MR. COBB: No, this is strictly an operating procedure.

MR. WARD: Sort of like us. He just advises.

MR. EBERSOLE: He stands there in a state of shock.

MR. KERR: I am not trying to be critical. I am just trying to find out what goes on.

MR. COBB: I wouldn't say that he would have any direct input into this procedure except for consulting with the watch engineer and the operating supervisor about what is going on, and if we see something that is not quite -- then he probably would have some input.

MR. KERR: Thank you.

MR. LEE: If I may go back to my earlier case, if the operator made the mistake of not throttling the high pressure injection system, and left it on, and the error is recognized a few minutes afterwards, would you then consult your shift technical advisor, or is it something of that nature, or do you have procedures to guide in that degree of detail?

MR. COBB: The procedure has already told him to terminate and prevent injection into the vessel. If he is dropping level and power is going down, and all of a sudden he gets the high pressure systems injecting and the power level all of a sudden goes up, he realizes that some place he has made a mistake in this procedure, so that when he loops back through his decision points that are in the EPG's, and I think they are all in contingency 7, he would realize that he had made a mistake, and he would be right back to that point where he would terminate and get that water out of there.

MR. KNUTH: I think your question is, if he turns on by mistake the HPCI, he will go back up in power, but he can only go back up to 30 percent of power or thereabouts because that is all of the flow he can get out of this HPCI. He will go up to 30 percent power and stay there until he cuts the level back down.

MR. LEE: But do you go through, then, this type of --

MR. KNUTH: His procedure would then recycle him back into an entry mode to then again tell him, lower water level.

MR. LEE: So in the ATWS emergency procedure guidelines, for example, does an operator have a chance to go through this type of unplanned action rather than following through a planned action?

MR. COBB: The guidelines take into consideration failures of equipment, operator failures, mistakes by the operator, but as I said before, there isn't enough time today for a full-blown discussion of the emergency procedure guidelines. We are just looking at how those guidelines would work controlling two mechanistic events, and you are just getting a small brush on the EPG's. You are not getting the full picture at all.

MR. KNUTH: One thing I think I am detecting, you have the feeling that these are ATWS procedures, that he has to recognize he has an ATWS. That is not the case. These are emergency procedure guidelines, and he doesn't have to say, ah, I have an ATWS, I will dig out a procedure called ATWS, or if you are with Westinghouse, ATWT. He goes to his emergency procedures, bingo, and he starts going through them. He does not have to say, today I have an ATWS, I will follow this procedure, whatever the number is. The procedure guidelines are structured so that that is not the case.

MR. MUELLER: They are symptom-oriented.

MR. KNUTH: They are symptom-oriented procedures. If he has a scram system, like he said, the three things happen, he does certain things. He doesn't have to consciously say, I am in an ATWS.

MR. LEE: One has to recognize that one is in an ATWS fast. Isn't that correct?

(A chorus of no's.)

MR. KNUTH: No, that is not correct. It is a symptom-oriented procedure. The procedures call for him to do certain things when he sees certain conditions in the plant, and he does not have to explicitly say, boss, I have an ATWS.

MR. LIPINSKI: But his symptom is that the rods did not scram.

MR. KNUTH: Well, he knows he has an ATWS.

MR. COBB: The symptom is that the APRM is above 3 percent. It is above the downscale trip on the APRM's. He doesn't even have to know his rods aren't in yet. That is an entry condition into the emergency procedure. When he goes into that emergency procedure for the reactor, he goes into level control, pressure control, and power control, and he controls all three of those at the same time.

MR. LEE: All manually.

MR. COBB: Basically. The first scenario I gave you, when he went into them all at the same time, he didn't have to do anything on level. Level didn't move. It stayed right there for the first part of the transient, because it was under control of the feedwater system, so he never had to do anything with that until he decided he wanted to put the boron in, and then level control is transferred into contingency 7, and contingency 7 is a power level control procedure. That is where you lower the water level and control the water level to control the power.

MR. WARD: Ed, may I ask a follow-up question? The two transients that you just described and walked us through, would those be absolutely identical EPG? I mean, was it a common set of symptoms for those two causes?

I guess of the seven things you said that lead you to a symptom-oriented procedure, I guess they would be the same for those two, as I understand it.

MR. COBB: The problem with event-oriented procedures, and I will address myself to the ATWS one, you need a procedure for 3 percent, 4 percent, 5 percent, and 6 percent.

MR. WARD: I think you are answering a more difficult question than I asked. This is a simple question. These two events that you described to us, did those literally have exactly the same set of symptoms? And did they literally lead the operator into the identical procedure?

MR. COBB: Yes, the symptom is power above 3 percent. You have a scram signal in.

MR. WARD: Any scram? It doesn't matter where the scram came from?

MR. COBB: Right. You have a condition requiring a scram. Your power is above 3 percent. You are into the emergency procedures.

MR. WARD: All right.

MR. PAGE: Could I amplify that a little bit, Ed, if I may? Correct me if I am wrong, but I think it applies also to some of the earlier discussions on water levels. Certainly you enter into identical procedures because the initial symptoms you are paying attention to are the same. You follow through because they are symptom-oriented. The symptoms of a turbine trip and an MSIV ATWS will be similar. One of the symptoms is, if you are following the water level as one of your symptoms, you won't have to lower the water level all the way to the top of the fuel if it is turbine trip bypass, but you probably would for MSIV.

It was sort of implied here. I don't think Ed said it. Maybe he said it, and I missed it, but I think the typical turbine trip with bypass, your 25 percent bypass, you would probably wind up only borating the water level slightly below your L2, a good bit above the active fuel, before your symptoms would say, don't do that any more, and start doing some other things.

MR. WARD: But that is a second level of symptoms.

MR. PAGE: That is correct.

MR. WARD: The first level of symptoms are the same.

MR. KNUTH: And the MSIV has to go further, because his SIV would not close. He kept dumping energy into containment so he has to go to the next step, saying, lower water a little more, so you are in the same procedure, but --

MR. WARD: You have gone farther down.

MR. KNUTH: Right.

MR. EBERSOLE: What happened to the reactor water cleanup system that is anxious to get all of the boron out as fast as you put it in?

MR. COBB: That goes right up front. When you shut the boron, as I said, when you start the boron, the next move is to clean up the isolator. That is an automatic action, I might add, but it is a step he verifies.

MR. EBERSOLE: How many APRM's does he look at?

MR. COBB: Well, broad spectrum, he has six APRM's. I would say an operator would be remiss if he didn't look at all of them.

MR. EBERSOLE: What if he was high on two but not on the others?

MR. COBB: High on two and no other?

MR. EBERSOLE: It could possibly indicate a partial stuck situation. I am just trying to find a difficult place.

(General laughter.)

MR. COBB: Okay. There are procedures. The MPG's address them.

MR. EBERSOLE: Did it say all of them?

MR. COBB: It says, if you don't know where your power is, then it addresses a way, because now the only thing you know, it could get into this, you don't know where your water level is.

MR. EBERSOLE: But you know you wouldn't dump boron in for just one of them showing up, because it could be a bad APRM, and I don't know whether you will go for two or three or six.

MR. BOUGHMAN: I can address that. If you had two APRM's that were reading high, the next thing you would hone in on is the local power range monitors, to see if they all had their down scale lights on. If the four that are down are right, you shouldn't see any LPRM's that are not down scale. They are right in the same vicinity as your LPRM indicators, so there should be no problem determining whether that is valid or not.

MR. KERR: Mr. Ward?

MR. WARD: There is one other point I wanted to pursue, Ed, if I may. Could we differentiate for a minute between EPG's, which I guess means emergency procedure guidelines, and those are the technical or process guidelines that I guess the vendors' groups are supplying, and then you as the operator will write something else. What do you call those?

MR. COBB: Emergency operating procedures.

MR. WARD: EOP's. All right. The point you made answering Mr. Lee's question about if an operator makes a mistake, he is led back by the procedure to a higher level, back up to correct that mistake, loop around, is that loop really in the EPG's or the EOP's?

MR. COBB: Right now, the only EOP's that are in --

MR. WARD: Well, will it be?

MR. COBB: -- that are in place that have been developed from the EPG's are from Revision 1, I believe it is, and it is all the NTOL's. I think there are six or seven of them. As far as I know right now, there are no EOP's. Are there any EOP's in service yet? I don't think so.

MR. KERR: I thought what you said is, you would be looped by recognizing the symptoms. In other words, for example, if you were feeding water, the power level would go back up to X percent, where X is bigger than three, and you would see this as a symptom, and you would say, I have got to do what the emergency procedures tell me to do if I have a power level of 6 percent. Isn't that what you were saying?

MR. DITTO: The plant closes.

MR. KERR: It isn't the procedure says loop back.

MR. WARD: But the process will tell him to go back.

MR. KERR: I think. That is the impression I got.

MR. COBB: Yes. The way this is structured, it is structured through giving instructions to the operator in case he makes a mistake, equipment fails, or whatever, so that he gets to a position where he shouldn't be. How he comes back and gets on the right track.

MR. WARD: Okay. But the point Dr. Kerr made is, he is reacting to another symptom or an unchanged symptom or something like that.

MR. COBB: All right.

MR. KERR: Other questions?

(No response.)

MR. KERR: Are you nearing the end of your presentation?

MR. COBB: Basically, it runs the same, with the only change being basically the temperatures. I could break here or continue this to the end.

MR. EBERSOLE: Bill, could you maybe modify your presentation to put you in the position of being in a plant that had steam turbine driven main water pumps?

MR. KNUTH: I will get into that right now.

MR. EBERSOLE: All right. You will be a

little bit less blessed with water, quite a bit less so.

MR. COBB: It is basically the same. If you want me to continue to the end, I will.

MR. KERR: I think probably that is far enough, unless some of you want to hear more.

(No response.)

MR. KERR: I think that was a very helpful presentation.

MR. WARD: Yes, it was.

MR. KERR: Are there any other questions?

(No response.)

MR. KERR: I will suggest a ten-minute break at this point.

(Whereupon, a brief recess was taken.)

MR. KNUTH: Digressing, I will now go through an analysis or present you the results of analysis of the timed cool temperature conditions for both the turbine trip and the MSIV closure when the plant has steam-driven feedwater pumps, which is the base case we had in our generic model, which was worse than if you have electric-driven.

I will not go through the operation action. Ed Cobb, I think, went through that in quite a bit of detail. I will indicated the timed temperature. Starting out at time zero, the pool temperature we assume for analysis purposes sitting at the LCO, which is 90 degrees for most plants, the maximum allowed suppression pool temperature in conditions for operation, the reactor is at 100 percent power. You get a turbine trip. You get an RPT.

As a result of the reactor pump trip, the power decreases to 25 to 45 percent. We now only use 40 percent power. The turbine bypass valves open to 25 percent.

We were talking this morning about generic versus plant-specific models. Some plants have full bypass capacity. Some plants have fifty percent, some sixty percent. Twenty-five percent is about the minimum. I believe there is one BWR in operation which has fifteen percent, but 25 percent is basically the lower side of the bypass capacity.

In this condition, as I say, we assume that reactor power settled in or dropped within a minute or very quickly would be pump tripped to about forty percent. Twenty-five percent of the steam goes to the condenser, where it is condensed and goes into the feedwater system and is pumped back. That means fifteen percent of the steam is going to the pool, heating it up.

Again at one minute, the pool temperature is heated up during the initial blow-down phase by about fourteen degrees. The temperature is 104 degrees at two minutes. Now you are bypassing about fifteen percent, again assuming the ARI is unsuccessful in getting a backup scram, a mechanical failure.

The pool temperature is increasing roughly 3.75, four degrees per minute, when you are sitting in this condition, bypassing fifteen percent of the stream to the suppression pool. The operator takes the actions at three minutes. Assume he starts the SLCS. He throttles the feedwater. He begins to throttle the feedwater at that time to lower the power so that his safety relief valve closes so he stops dumping energy into the wet well.

The pressure vessel continues to drop and he is monitoring conditions. At five minutes he peaks out at a temperature of 119 in the pool and his power is down to 25 percent, and from then on he is sitting in basically a stable condition, dumping boron into the system, dumping energy into the condenser. The pool, since he did put on his RHR at three minutes, the pool temperature begins to turn around at ten minutes or thereabouts. It does not come down very fast.

The RHR system is not that large a heat removal system. It is large, but not that large, and at 28 minutes, assuming 25 minutes to inject sufficient boron to take you to hot shutdown, the transient is basically over. You are sitting at hot shutdown. The rods are still anchored in their stuck-out position and, of course, you continue injecting the boron until the tank is empty, which is something on the order of perhaps ninety minutes to one hour.

It holds about four to five thousand gallons of borax and boric acid and it pumps in at 43 gpm, so it is somewhere around 100 minutes before you terminate the pump. We looked at this and said assuming the operator did not take action for the first ten minutes -- he just let it sit running forty percent of power where the power levels out -- what happens if he enters this procedure in ten minutes, and we find the cool temperature peaks out at about 150.

Yes, sir?

MR. KERR: You assumed an added-degree initial temperature. What did you assume about the pool level at the start?

MR. KNUTH: The pool level was at the normal, the lower level. We used, I believe, 60,000 cubic feet of water.

MR. KERR: There is an LCO on the pool level also?

MR. KNUTH: There is a maximum and minimum level.

MR. KERR: You assumed you were at the minimum, maximum, or somewhere in-between?

MR. KNUTH: Actually the minimum. The calculation I did was 60,000 cubic feet.

MR. KERR: 60,000 cubic feet. You mentioned boric acid or borax. I had a vague feeling that the boron in this case was in the form of sodium pentaborate.

MR. KNUTH: That is what it is. That is a mixture of fifty percent boric acid and fifty percent borax, I believe. Is that right? No?

VOICE: That is how they make it.

MR. KNUTH: It is sodium pentaborate. That is the official title of the poison in the tank.

MR. KERR: I am not much of a chemist, so I perhaps do not recognize the synthesis procedure.

MR. DAVIS: Excuse me. I had a question. I believe Mr. Cobb said one of the first activities will be to send people out to see whether they can correct whatever the malfunction was in the scram system. Presumably that would occur before the operator attempts to actuate the standby liquid control system, will it not?

MR. KNUTH: The procedure is very specific as to what an operator and controller are supposed to do. As part of our petition,, EPGs are basically independent. Part of our position was procedures and training would be developed to respond to an ATWS event.

It is our firm belief that when the operator sends -- when the operations supervisor sends an operator out to bleed off air off the headers or to manually try to get the rods in, they will will in the control room adhere to the procedures and will in fact inject the boron when the procedure calls for it, irrespective of what action is being taken elsewhere.

MR. DAVIS: You do not think they will be inspired to wait and see?

MR. KNUTH: No, sir, I do not think so. Our goal and what we were aiming for -- let the operations people speak.

MR. COBB: The emergency procedures, as written, direct two paths to occur concurrently. Inject the boron and use alternate actions to get rods in, and there would be no hesitation on the part of the operator to follow the procedures, as written.

MR. DAVIS: Thank you.

MR. KERR: Maybe I am pushing things a little bit too far, and I will not go further, but if one sees that the rods have been injected through some mechanism or another, does one then immediately cut off the boron, stop injection?

MR. KNUTH: I do not know whether the EPGs call for cutting off boron. The EPGs have additions when they enter them.

MR. COBB: Would you please repeat the question?

MR. KERR: Suppose that one had begun the injection process and was then successful in getting rod injection measured by some reasonably valid system. Would one not then stop the boron injection, or is that something yet to be decided?

MR. COBB: When all of the rods are in beyond 06, typically 06, basically the transient is over because the reactor is now subcritical and the boron injection could be stopped. I would have to take a look at the EPG just how to handle that, and I do not want to say right off the top of my head.

MR. KERR: I would not think you would. Thank you.

MR. KNUTH: Looking at the next step, considering this BWR ATWS scenario, as you recall the original result, we ended up with assuming that the operator had a 99 percent chance of not doing it correctly, that you were going to have a risk of 4.1 times 10^{-5} at the utility fix, assuming no operator action.

Recognizing that turbine trip comprises about seventy percent of all of these transients and assuming that you can take with EPGs ten minutes before you initiate the emergency action procedures, then this corresponds to a human error probability of 16 percent and applying that in the methodology we used, you would end up with an overall risk of 1.6 times 10^{-5}, which says that going to our next transient we would basically assume they would always end up in failure, that you exceed 200 degrees or whatever limits, although, as I say, we do not really believe it means failure.

Yes, sir?

MR. LEE: You are using 200-degree temperature?

MR. KNUTH: We did not use a temperature, basically, but the temperature in these end up at about 150. I will give you the temperatures you get for the next series of transients, which are the more demanding and more serious ATWS, if you will, because they are the main steam isolation valve, which puts the most burden on, so far as containment pressure, because you have isolated your heat sink condenser.

MR. LEE: And what kind of transient are we discussing here?

MR. KNUTH: This one was the turbine trip with the 25 percent bypass to the condenser, and using the EPGs to control power and level so that you dump a minimum of energy into the tank.

MR. EBERSOLE: May I ask a question? Go ahead, Dave.

MR. WARD: Don, the plants -- you said there are some plants with 100 percent turbine bypass.

MR. KNUTH: Ninety-five percent, yes, close to it.

MR. WARD: There are some plants which have, you said, 95 percent?

MR. KNUTH: One of the Brunswick units has very high bypass and the other is like sixty percent. There are variations at various sites, yes.

MR. WARD: Would the EPG for that plant be essentially the same?

MR. KNUTH: In terms of reducing power?

MR. WARD: Yes.

MR. KNUTH: I believe the EPGs would probably be the same, but in a situation like that your safety relief valves would not have opened, so you would not be required to lower level because the EPG basically says that if your safety relief valve is open, you are at power. You reduce water level until your safety valve reseats or recloses and you are not dumping energy into the containment.

Basically in a situation like that, where you could handle over forty percent of the flow, you would have no reason to lower water level

MR. KERR: Mr. Ebersole?

MR. EBERSOLE: Having now highly borated the system, have you looked at the response of the instrumentation control system to see that it will not be bothered by being borated with the problem of solidifying or plugging the lines or so forth? You have excess flow checks and so forth all over the place?

MR. KNUTH: Bear in mind the boration in this situation, when you are fully borated with a tank fully empty, you are somewhere in the vicinity of 1,400 parts per million boron. That is less than what you have in a normal operation PWR. The amount of boron concentration is not as loaded as you might think.

MR. EBERSOLE: Is it compatible with the temperature distribution of the systems?

MR. KNUTH: I would refer to someone from GE. I had not specifically looked at that. My off the top of my head reaction --

MR. KERR: GE, do you understand the question?

MR. EBERSOLE: For the boron concentration, you will ultimately obtain, are the temperature distributions throughout the plant such that you will not get boron fallout or sedimentation? You will not botch up your instrumentation system, including excess flow checks and so forth?

MR. ROGERS: You say once you have started injecting boron?

MR. EBERSOLE: Once you have finished it and are now sitting fully borated.

MR. ROGERS: The boron concentration in the slick tank is such that that is the maximum concentration you will ever see in a reactor, and you need about 100 degrees to ensure that the boron stays in solution. If you could get some portion of the RPV primary system down to sixty or seventy degrees, you might see some precipitation, but it will be mighty tough to see that even in a small instrument line for a long, long time after the ATWS, and at that time you should have other problems.

MR. EBERSOLE: Thank you.

MR. KERR: Other questions?

(No response.)

MR. KERR: Please continue.

MR. KNUTH: Looking at the transient now that I am sure you have the highest degree of interest in, the more limiting one, this is the MSIV closure ATWS, and again starting the event from basically ninety degrees, limiting condition for operation, again 100 percent power. The MSIVs trip. The pressure increases again. Power settles in to 25 to forty percent.

In this instance the feedwater goes to zero fairly rapidly. There are steam-driven feedwater pumps. Doing our calculations that we have done, which you will see here, we basically used the GE-calculated numbers from NEDO-2422. In calculating, we smoothed the transients that appeared from those graphs, but we used basically the input from GE. We used basically the input that the EPG group provided to the NRC in terms of power versus flow and so forth.

And I will show you basic input data that we used. In this particular instance, we are continuing to basically put all of the steam that is generated in the primary system into the wet well. Again, the operator actions. Mr. Cobb went through what the actions would be.

In this particular instance, the temperature would peak out in the wet well at about 221 degrees by following the EPGs. This assumes that at ten minutes you have lowered -- the rocedures allowed you to lower the reactor water level near the top of the active fuel and the power level has settled out at about eight percent.

I have some sensitivity studies here to show you what the temperature would go to if you maintained a level at other than top of the active fuel, if your power was more than eight percent.

MR. EBERSOLE: Does he have to maintain water level by turning HPCI off and on?

MR. KNUTH: He would basically turn off, throttle back or shut it off until he got the level down to the top of the active fuel. He would either use RCIC and HPCI where the system is pressurized. The answer would be yes. He would use his high pressure injection system.

MR. BOUGHMAN: No.

MR. KERR: There is the man over there, Mr. Ebersole.

MR. BOUGHMAN: The MC turbine and the RCIC turbine are both variable speed turbines and they both have the capability of controlling the feed to the vessel by controlling the speed of the turbines driving those pumps. The controllers are located on the control panel and you can ramp the speed up and down as you want.

MR. KNUTH: I thought that was what I said. You control the level with the HPCI turbines.

MR. BOUGHMAN: But he wanted to know if you had to keep shutting it off and on.

MR. EBERSOLE: It is not cyclic. You just modulate.

MR. BOUGHMAN: Right.

MR. EBERSOLE: Thank you.

MR. KNUTH: The reactor power estimate as a function of time in this particular transient is shown in this chart, and the upper curve and the lower curve are pretty hard to see, but basically the upper curve is a smooth curve that you would obtain from the NETO 2422 document where basically your system is attempting to control water level to its normal level.

In this particular instance, the HPCI flow basically goes -- you go through a transient. The HPCI recovers level. It basically will hold the level basically at its normal water level and you end up at an equilibrium power level somewhere around thirty percent. This is what it would look like if it were a smooth curve and you are not putting -- no boron was entering the reactor level.

For the EPGs, the power level if you get down to it immediately -- the power level would come down and settle out at about eight percent, which is the top of the active fuel, and we have developed sensitivity studies assuming he enters and begins controlling level and injecting the boron with a two-minute delay and a ten-minute delay, which means he would come out to about here and then go on to it.

And we did calculations of what the pool temperature would go to under these various scenarios, and I have some curves that we used for power versus level above the active fuel, if you were interested. But in the interest of time, I will go on to the sensitivity.

Basically these are the sensitivity curves. I will call them estimates. They are hand calculations, taking smooth curves, as I have shown you here, and calculated what the temperature would be in the pool by following the EPGs, and you see with the BWR-5 or 6, the temperatures are somewhat lower, mainly because the HPCS flow is somewhat less than the HPCI flow.

And you enter the procedure late. You have not recovered level nearly as much as you would have in the BWR-4, where you have the very large HPCI flow of 4-5,000 gpm, depending upon the plant. And this assumes both the HPCI and the RCIC are both on, delivering their maximum flow at related reactor pressure.

What you see is the temperature, depending upon when he initiates or when he begins that procedure. The base case I showed you earlier was 221 degrees. If he delays that ten minutes, it is 264.

MR. EBERSOLE: Do you encroach on the NPSH margins on the pumps?

MR. KNUTH: We have calculated the margins on the HPCI pumps and the RCIC, which have the highest NPSH demand. There is 21 feet required head. In order to get the temperature of 221, you had to pressurize the containment. If you did not pressurize the containment, you would have a problem. But if the containment pressurizes and you calculate the pressure corresponding to 221, you will not have an NPSH problem.

The pumps will continue to have adequate section head.

MR. EBERSOLE: Integral, then, is the thesis you will always pressurize.

MR. KNUTH: If you do the calculation using the standard safety guide 1, which says you use atmospheric pressure and calculate temperatures at atmospheric pressure, you will lose NPSH, but it is not the real world. You will in fact pressurize the containment.

MR. KNUTH: I also did the calcul[illegible] sort of in anticipation, I guess, and we did some calculations earlier using different power curves. But if you didn't control the power level and you settled in at 15 percent rather than 8 percent, what kind of temperatures would you get in the pool under the same identical conditions?

These are the values you would end up with in a BWR-4 and BWR-5. Questions?

MR. KERR: Are there questions?

(No response.)

MR. KNUTH: That sort of -- well, that does complete our discussion of the use of the EPG's.

The next part --

MR. LEE: May I?

MR. KNUTH: Sure.

MR. LEE: So what you are saying, even though you do maintain the normal water level, the incremental temperature change that you have to contend with is on the order of ten degrees Fahrenheit, the maximum temperature?

MR. KNUTH: From the normal water level? No.

VOICE: That is delay in initiating the procedure.

MR. KNUTH: This is delay in initiating the procedure. If you were to maintain normal water level, which means you let the HPCI and RCIC pumps pump at their maximum flow, you will end up at 31 percent of power. The level will seek that power level. Dumping that energy in the containment, you will end up with a temperature of 283.

If you followed the EPG, you would end up basically in this condition at 295, because the procedure in EPG does call for depressurizing the reactor vessel once the containment temperature starts approaching 160. So in that particular case --

MR. LEE: So you end up with an even higher temperature.

MR. KNUTH: You would up with a higher temperature because you have intentially depressurized your vessel, yes. If you want to compare numbers, what you would gain by reducing power in the 15 percent case, you would be looking at these, right. EPG with no blowdown, which is an artificial case, the procedure does call for blowing down the primary utility for pressure.

I should be showing you the one at eight percent, because that is really the correct case. And the top line is the same in both cases. These are numbers basically from the first two numbers of the basic cases from the NEDO document.

MR. LEE: So the middle lines?

MR. KNUTH: Are the EPG's, correct.

MR. LEE: That is your best estimate?

MR. KNUTH: That is the best estimate, yes.

VOICE: I just wanted to comment, the MSIV closure event is the most limiting event. That is the EPG without lowering water level, which in effect is not the EPG, and it is a ten-minute delay.

MR. KNUTH: No. It's lowering water level.

VOICE: At ten minutes.

MR. KNUTH: He doesn't enter the procedure until ten minutes if he enters it the way he should. If he delays two minutes, it's 176. And I guess that would actually be 221, because the procedure for most plants would call for a blowdown basically when the containment temperature wetwell approaches somewhere around 160. The EPG would call for beginning to lower pressure in the primary system.

MR. KERR: Does that answer your question?

MR. LEE: (Nods affirmatively.)

MR. KERR: Are there other questions?

MR. KNUTH: Bear in mind, these are hand calculations based upon smooth curves and so forth.

MR. KERR: Mr. Davis?

MR. DAVIS: Don, I thought that the RCIC would trip on high back pressure --

MR. KNUTH: It will.

MR. DAVIS: -- as the suppression pool temperature increases, and that will be a self-limiting feature of this kind of a transient, won't it?

MR. KNUTH: The RCIC will trip, as I recall, at 55, 60, I don't know, psig. The HPCI is way higher. You don't need the RCIC to deliver eight percent flow. HPCI will handle it it trips at a much higher pressure, 150 or something like that.

MR. DAVIS: What I'm saying is, the tripping of RCIC helps you.

MR. KNUTH: In this case, yes. You would probably ultimately trip off, the RCIC would trip off well before you got to the maximum temperature, that's for sure.

MR. DAVIS: So it is conservative.

VOICE: The RCIC would trip at 25 pounds.

MR. KERR: Other questions?

MR. EBERSOLE: Yes. Do all of our operations hinge on the thesis that we will successfully cyclically operate the safety relief valves and none of them will stick open?

MR. KNUTH: No. If a valve -- let me go

through it again. The EPG's, when the containment wetwell temperature reaches somewhere around 160, the procedure calls for opening an SRV and begin lowering reactor pressure. The idea is to keep away from the Wurgassen effect.

So if a safety relief valve were to stay open, it would basically put you in that mode of the procedure somewhat earlier than you might want to get into it, if you want to think of it that way.

MR. EBERSOLE: It would also prevent you from using RCIC and HPCI.

MR. KNUTH: Once the pressure dropped -- HPCI is designed to operate down to 100, 150 psi steam pressure. So at some point in time when pressure gets low in the reactor system, you have to switch over to a low pressure system. And again, the EPG's have basically, the curves you are talking about, mph limits in them as to the temperature and flow limitations on use of that equipment.

MR. EBERSOLE: Where would you get the low pressure water now? You would not open the RHR system, would you?

MR. KNUTH: Let me ask an operator.

MR. BOUGHMAN: Gary Boughman.

You have several sources you could use. The preferred source would be to use the condensate pumps. If you depressurize, you might have enough voiding to be able to stay up with the demand on the condenser hotwell with your normal makeup system. That would be the preferred path.

You could also use the four-spray system. You could use RHR if you wanted to. There's a number of ways to get water into the vessel.

MR. EBERSOLE: You would be manually controlling the level with these pumps.

MR. BOUGHMAN: That's correct.

MR. KERR: Mr. Lipinski?

MR. LIPINSKI: You have EPG, EPG no blowdown. EPG is your normal procedure, is that right?

MR. KNUTH: EPG is the procedure. EPG blowdown -- I just wanted to be able to compare the top two, because the top one, "Maintaining normal water level," did not envision in the original analysis a blowdown of the primary system in containment. It is an artificial situation.

The EPG's would in fact call for you to open the safety relief valve when you got containment temperature above 160. So in fact, these are the numbers you should be looking at for the EPG's.

MR. LIPINSKI: The next question is, given these numbers, how do you relate them to NRC's requirement of a 200-degree temperature?

MR. KNUTH: It's consistent. If the requirement is, thou shalt not, from a licensing condition, exceed 200 degrees, this means failure every time, and that is what our analysis did in fact do.

MR. LIPINSKI: So even though you have automatic injection with a zero time there, you will still reach 211, 202?

MR. KNUTH: In this?

MR. LIPINSKI: Yes.

MR. KNUTH: Yes, correct. This is 43 gpm, again following EPG's, yes.

MR. LIPINSKI: What happens if you go to 86 gpm?

MR. KNUTH: I have some sensitivity calculations somewhere in this maze of slides.

MR. LIPINSKI: Given the zero time delay, the gpm really doesn't enter into the picture. You are still at the 202-211 limits.

MR. KNUTH: This is a comparable calculation done assuming you had SLC with equivalent 86 gpm. I say equivalent because you are getting boron at the rate of a normal concentration, pumping at 86. Most plants couldn't physically do it because the system couldn't handle it, but you could raise the concentration.

But putting that rate of boron injection in or, saying it another way, instead of 25 minutes for injection, if you reduced the time for injection down to 12 or 13 minutes, these would be the temperatures you would end up with as a function of delay time.

MR. LIPINSKI: Then I am misinterpreting time delay. Is time delay the time that the injection starts?

MR. KNUTH: It is the time the operator enters the procedure.

MR. WARD: Those are peak pressures, given the different time delays.

MR. LIPINSKI: Okay.

MR. KNUTH: It is the peak temperature assuming that the operator --

MR. LIPINSKI: Thank you.

MR. KNUTH: The only reason for this is to come up with a human error probability. Ten minutes gives you a different factor to be used in the risk study.

MR. LIPINSKI: So at 46 gpm you cannot meet the NRC 200-degree requirements?

MR. KNUTH: For the MSIV closure, and those are the numbers we are going to use in the value impact which you will see next.

MR. EBERSOLE: Could you give me the reason one does not use a higher concentration boron solution than we have for our absorption cross-section using isotope mixtures?

MR. KNUTH: A practical consideration is, you would have to heat the tank, like I said.

MR. EBERSOLE: That is just a straight higher concentration. I am talking about even an isotopic arrangement.

MR. KNUTH: I believe the expense. It's somewhere in the vicinity of a million dollars to get your concentration in the tank up using, say, 40 percent enriched boron instead of the normal boron. It is very expensive to buy.

MR. EBERSOLE: The solution is expensive.

MR. KNUTH: Turning now to the value impact --

MR. KERR: Mr. Knuth, before you get to value impact, help me remember what the operating group's proposal was, 43 or 86?

MR. KNUTH: 43.

MR. KERR: All right. Then explain to me what your understanding is of how a utility group concluded that those temperatures above 220 or so were temperatures with which they would be willing to live from the fact that they have to operate and live with these plants?

MR. KNUTH: From two aspects. We believe that the probability of the transient is low enough that by putting in 43 gpm -- and you can consider, if you wish, from a design basis standpoint that MSIV closure to exceed 200 is "an unacceptable consequence". The cost-benefit, as I will show you, would show you that is adequate.

It is my belief --

MR. KERR: I am sorry, you lost me somewhere in the logic process. If you believe those numbers, those temperature numbers, then it seems to me you must also believe that the system, quenching system and so on, operate properly without coming apart or whatever.

MR. KNUTH: I do.

MR. KERR: And I am asking on what basis you reach that conclusion.

MR. KNUTH: Okay. We have done calculations of the -- assuming that the containment pressurizes, and have looked at the margin of subcooling we have at the point these quenchers are submerged under the water. When you take credit as you heat up the water and repressurize the containment, you always have an adequate margin of subcooling, where the steam is discharging under the water, to prevent this Wurgassen effect.

We believe the containment will pressurize. It won't stay at atmospheric pressure, and it is not a problem in repressurizing the containment.

MR. KERR: From the beginning of the study of the performance of suppression pools and quenchers, it seems to me one can trace a history of calculations not being borne out by experience. And if we didn't have a good many confirming experiments, it seems to me we are on shaky ground.

It seems to me you are in a region where the experimental data are either nonexistent or very sparse, and I guess I am a little leery of calculations, having seen calculations in the past which proved to have neglected something fairly important.

MR. KNUTH: Where they have experienced the difficulty with the Virgosson is in those plants where they have not had the quenchers. Those plants -- and I agree with you, it is all conducted at atmospheric pressure, the test data on the quenchers. And for those where you have 10 degrees of subcooling or thereabout in margin, you do not have the Virgosson effect. You do get that degree of subcooling as long as the containment will pressurize.

And we have discussed this with GE and they believe that in fact the Virgosson effect -- there's no reason you should have that effect as long as you have a local subcooling of ten degrees, say, and you do have it.

MR. KERR: Well, having been raised as a Southern Baptist, I am a great believer in the efficacy of faith. But I also like experimental data on occasion.

MR. KNUTH: There is no experimental data. There is some, but it is very sparse.

MR. PAGE: Don?

MR. KERR: Mr. Page?

MR. PAGE: Dr. Kerr, listening to your original question, I am guessing at the basis of it. I think what we have done here is to apply EPG's to what we consider to be the most likely transient, turbine trip bypass, which is obviously a lesser transient. And as you recall the earlier slides, every situation meets the 200-degree limit. That is the only credit we have taken.

MR. KERR: I am not talking about credit and regulation. I am talking about a power plant with which you will have to live for 40 years and which might experience an ATWS. Now, you have done some calculations which presumably have convinced you that the performance of that system is acceptable.

MR. PAGE: We do not presume the performance of the MSIV closure is acceptable. If we take no credit for that and look at the risk we wind up with, it's about the same risk level the NRC Staff is getting for 86 gpm and no credit for operator action, because there was no credit for operator action there.

We have it for turbine trip. What Don is saying, we think even though we take no credit for MSIV, there is a likely chance we could even survive that. But we take no credit for it in our risk numbers, and we feel our risk numbers are low enough without it.

MR. KERR: So you are willing to live with the risk you have calculated, even though you get these high temperatures?

MR. PAGE: It's about the same ballpark for the MSIV closures, that one transient, because it's a much lower probability transient.

MR. KNUTH: We have assumed that all of the MSIV initiating events end up in failure, and the risk is still low enough because the predominant transients are the turbine trip ones. But we do believe that the MSIV, you can still live with it. It is not a cliff.

this 200 degrees is not a cliff and when you get to it you fall off it.

MR. KERR: Someone, some time today, will explain to me how the utility group reached their own safety goal in terms of risk, because we are using the term "low enough". Is someone prepared to do that?

MR. PAGE: Roughly.

MR. KNUTH: We will try.

Moving to the value impact, I will try to cut short, I think. The presentation Bob Bernero gave will allow me to pass over a large number of items we have here.

I will reiterate that the assumption we have used in our value impact in every instance was that unacceptable conditions, being "the worst case ATWS event", we attempted to determine a value for that. And I must say, we have been subjected -- I have been subjected to a lot of criticism for using this high side value.

I picked it, chose it or calculated it from the numbers that appeared in NUREG-0460. There is certainly a large segment of the industry that believes that the values used in the value impact should only include the health and safety effects. We believe a large amount of the value of $10 billion comes from basically writing off the plant and purchasing replacement power for ten years, which would correspond to perhaps $8 billion of that. And many people in other forums are arguing that economic things that will cost the utility money which are not direct safety concerns should not be factored into a cost-benefit.

Be that as it may, we have used the number the NRC used in the original 0460, for the same reason we used scram failure rates: We didn't want to prolong the arguments. We wanted to use numbers. And we believe that even using these numbers we end up with a value impact that justifies our particular position.

On cost data, you had a few questions on that. I will briefly go through, I hope briefly, the cost data, particularly for the GE case, the boiling water reactor.

This first slide lists the initial impacts in terms of: the hardware costs; the AFUDC, which is basically interest charges during construction; what the cost would be in terms of radiation exposure using a 1,000 rem per person per installation, which is zero; in replacement power during the installation of the RVD and SPT.

Realizing this is an average, we collected the data from a number of utilities. The costs were variable. Plants that were still under construction, where it could be scheduled, would end up with a perhaps zero replacement power cost. It could be done before the plant went on line. Plants in operation, where they are already schedule up to the hilt -- and certainly one of our utilities has its plant down today. He has over 3,000 construction workers installing post-TMI items in it. He will be shut down for three months. To go ahead and schedule putting in something else means you would have to hold the plant down longer to get more people to work in there.

This is sort of an average from the members of our utility group. The hardware costs, as Bob Bernero correctly pointed out, are not trivial. But looking at the overall costs, they do not come up to the cost you get for the replacement power when you are down putting in equipment or the inadvertent trips. Putting in trip signals will end up tripping the plant sooner or later.

And we attempted to cost all these things out. Inadvertent trips, for example, we assume that the equipment, RPT ARI, would end up causing a spurious trip once every ten years for a two-day down time. The cost we used for down time was, we think, very conservative, $500,000 a day. Most utilities would tell you to have a nuclear plant off line today costs more like $870,000 to

$1 million per day.

In any event, the utility rule for the hardware was $11.5 million to install utility ATWS fixes. We also looked at and provided numbers on the NRC alternative 3A and alternative 4A, putting in an automatic boron injection system, your Hart-Capaski boron injection system.

Again, we believe we used very conservative, low-cost values to shade the value impact in favor of moving toward the NRC's position, mainly to mute arguments. The overall result of the value impact we have published in our report is the utility rule. The impact cost, $11.9 million. You saw the earlier one was $11.5 million. We felt it would be another $400,000 for the training and developing procedures to implement EPG's which came in later in our amendments.

The value, using the risk values, the original risk value was, you recall, 4.1 times 10^{-5}; with EPG's, about 1.5 times 10^{-5}. This gives you the value impact.

Moving then to implementing beyond the utility rule, the Staff's rule, and again using risk values, in calculating the value from NUREG-0460 and actually improving their risk values, lowering it even further, we find that the impact to install the equipment would be about $27.5 million for 3A; the value, anywhere from a factor of three to ten less.

4A in our view is even less effective. It is nearly $40 million to put the equipment in. We have done similar work for the PWR's. I will just show you the summary, the individual tables. There is a table for each vendor in the report. GE's is Tables 4 and 8. Westinghouse, CE, and B&W are in numerical order.

Here we have given the incremental value impact of the utility rule for Westinghouse. The cost is much more in the value impact statement. We don't even believe that putting in the Westinghouse -- putting in the utility amendments in Westinghouse is worth it from a cost-benefit standpoint.

It is certainly very marginal in the Combustion and B&W case. The risk is already low and it is about a one to one ratio. The ratio is about one. It is marginal whether it is worth it in our opinion.

3A, clearly the value impact for Westinghouse is not there. The Staff 4A is basically the same. And again, the Staff 3A is basically the same as the utilities's position, so we did not give any additional values. But clearly the Staff 4A from a value impact standpoint was not worth it.

Again, I think -- and I resurrected this slide at the last moment because the value impact ratios were shown by the Staff. These would be the values that we would calculate using utility-generated numbers. Again, GE is the only one that would show that the value impact would let you put in the utility fixes, moving to 3A and 4 and certainly the Hendrie rule are not worth it.

MR. KERR: CE appears to be slightly bigger than one.

MR. KNUTH: Yes, very marginal. The value is about equal to the impact. It's marginal.

MR. KERR: What confidence do you have in these value impact ratios?

MR. KNUTH: I approach that one with fear and trepidation. The calculated values, I just don't know. We think that the costs -- where the impacts are on the low side, we believe the value, the way we have calculated $10 billion and the way we have calculated the events, it is on the high side. We believe that these are conservative in that they drive the ratios high.

MR. LEE: On a relative basis, if I may pick up Westinghouse's case, if I remember correctly the bulk of the costs associated with the Staff rules are really the analysis cost.

MR. KNUTH: Correct.

MR. LEE: And if you can take away the $5 million --

MR. KNUTH: It's not much.

MR. LEE: Then the cost estimate, the value impact ratio for the Staff's 3A rule looks very similar to your amended utility rule, right?

MR. KNUTH: Correct, yes. We believe the estimates we have for developing design basis models and dealing with many utilities who purchase reload calculations, a million dollars to develop and validate a computer model to do a design basis analysis is not that far out. I was with the NRC funding friends out in Idaho and other places to develop computer models, and I know how much it costs to develop a computer model, validate it and make sure it is doing what it is supposed to do.

And certainly, the recurring costs for reloads are a real cost. $400,000 per reload is not a far-out estimate.

MR. LEE: So if the NRC Staff is willing to adopt a generic analysis and perhaps evidence submitted already to Staff to a large extent -- for example, Westinghouse has no problem with the analysis that has been submitted to Staff already.

MR. KNUTH: I was very gratified to hear today that it looks like perhaps no analysis at all would be required. I think we applaud the Staff in moving in that direction. We certainly don't believe there is a need to do any further analysis. The analysis has been done, submitted, reviewed, and re-reviewed. We think that the calculations are on the record and one can develop criteria, prescriptive criteria based upon what has been done today.

MR. LEE: So some of these might be already moot?

MR. KNUTH: Well, I hope so. I hope the Commission and the ACRS supports the concept that design basis analyses are not required for an ATWS. It is certainly a big hitter in terms of costs to perform those things, and it chews up resources, manpower and talent.

MR. EBERSOLE: May I ask a question? Talking about the cost of replacement power or outage time, how did you factor into the problem the fact that you are shut down a substantial fraction of the time anyway, and you probably could avoid line delays if you worked at it and had time to work it in?

MR. KNUTH: What we attempted to do, and this is difficult, we in our group pretty much are convinced for those plants, and most of the people sitting in here have operating plants, if the NRC were to say within the next three years, please instal an ATWS mitigator, that is going to mean either taking something else off of the refueling outage schedule, which is not very likely, or it will extend the outage. The people we dealt with, the schedules, the planners felt very strongly that they are already up to their ears in installing various pieces of equipment, improved auxiliary pumps, what have you.

As I said, one utility I visited last week has on site 3,000 people. He will be shut down for three months, and that exceeds the number of people he had there during construction, and they are putting in mods from Three Mile Island. If you schedule something more, it will just take more time. We think six days, for example, was fairly low. Many utilities told us if they had to put in a pressure relief valve, it could be as much as 30 to 40 days, once you consider all the hydro and sequencing the stuff in, and being able to get the people, the bodies, the welders.

I have to admit it was tough coming up with these estimates. There was a lot of disagreement within our group. There was a lot of variability in our group. These are averages. We did the best we could.

MR. KERR: Are there questions?

(No response.)

MR. KERR: Please continue.

MR. KNUTH: I have reached the end of my string, and I didn't mention poison pen letters, either, Bob.

MR. KERR: I have an item here called Comments on Utility Group Presentation, if any.

MR. LIPINSKI: Before he leaves, I had a question.

MR. KERR: Let me ask, are there any?

MR. PAGE: No prepared comments.

MR. KERR: I don't want to insist on comments. I just saw it on the agenda and didn't want to ignore it. You had a question, Mr. Lipinski?

MR. LIPINSKI: Yes. When we were discussing the questions of MSIV closures versus turbine trips, I thought you said something about you were going to show that in the value impact, but nothing you have discussed now differentiates between turbine trips and MSIV's.

MR. KNUTH: What I meant to say was, the probability we use in calculating the value side equation is 1.6×10^{-5}. That assumes that the MSIV closure event ends up in failure every time, that it ends up in consequences, "unacceptable consequences" because it exceeds 200, not because it exceeds 200, but because we assume it is an unacceptable consequence.

MR. LEE: So that position is a little bit different than the latest submittal.

MR. KNUTH: That is correct. This is based upon our understanding. We have been doing a lot of work trying to understand, as have other people, the EPG's, how they work, how the operator responds.

One thing I would also like to point out is the human factor probabilities we use. We are basically assuming a single operator. The Swain-Gutmann is basically a single operator responding, and as you heard from the presentation, you will not have a single operator, you will have an army of them. That is better.

MR. KERR: Do you think a single operator makes more or fewer mistakes than multiple operators?

And I don't ask the question facetiously.

MR. KNUTH: I think when you have a senior oprator, a watch foreman, the talent you will have in the control room, I think you are better off. You have more people to look to make sure that things are on the right track. You have basically the STA, who is an observer, and basically will not discharge any responsibility. He is giving advice.

MR. KERR: I must say, I didn't get a very sanguine view of the contribution of STA's from Mr. Cobb, but maybe I misinterpreted his presentation.

MR. LIPINSKI: Let me comment and draw a parallel. If I have three channels, and they are independent, you take their products and multiply them together, but when you look at the spurious contribution rates, as soon as you triplicate it, you have three times the rate you do for one channel, so the probability they may do something right may go as something cubed, but the contribution of spurious and wrong action could triple.

MR. KNUTH: The only area where I have seen this come up is the continual hassle between the FAA and the Airline Pilots Association, where they have looked at aircraft accident records with two pilots in the cockpit versus requiring a third flight engineer sitting in there, and they always bring out the DC-9 versus the 737 accident rate, and if you have three people it has a lower accident rate. Is it because you have three people there? Maybe. Maybe not. I certainly think the more talent you have in the control room, the better off you are. Having a single person is the least desirable. That is my personal view.

MR. KERR: Do you think they could call a committee meeting, perhaps?

MR. KNUTH: They will get in a fist fight, perhaps.

MR. LIPINSKI: They could call the NRC.

MR. KERR: Mr. Ebersole?

MR. EBERSOLE: Before you get away, regarding the little conversation a while ago, years ago, I sort of felt like the MSIV's were too anxious to close beyond the hope of getting open again, and much talk was generated about a forced bypass, and we touched on that topic a while ago. The fact that they are so enthusiastic could get you in big trouble. Did you wrestle with the concept of having an optional way to get steam to the condenser than what you have now?

MR. KNUTH: Not from that standpoint. We looked at it a little bit differently. We are mindful in our group of the efforts the BWR owner's group has had with the NRC, and this touches on somebody's comments a while ago about reducing the number of transients. One of the recommendations before the NRC is to lower the set point when the MSIV's close from the L2 level to the L1 level. Anyway, it gives you an additional five feet that the water level has to drop before that isolation signal comes in.

This recommendation is before the NRC. We are mindful this is one of the things the BWR owners and utilities are looking at, and I think some of them have already implemented it. Some are in the process of implementing it, and the primary objective is not from this standpoint, but to reduce the number of MSIV events.

MR. EBERSOLE: I know, but I am talking about the option of getting back the condenser, even if you have locked out the MSIV by enlarging the equalizing stream you already have.

MR. KNUTH: I could talk to an operator, but I know it is tough to open them. Go ahead.

MR. BOUGHMAN: The MSIV's, as you say, are very anxious to close, and in a particular type of event we are talking about now it would be a luxury to be able to reopen that after it has happened, even if you have the water level down. How expensive a fix like that is, I don't know.

MR. EBERSOLE: You already have a bypass. It is just a very small one.

MR. BOUGHMAN: Yes, it is a small one, and it would take some time to pressurize downstream. The larger bypass will allow us to get pressurized more quickly, but we would still need a way to override a level lock if we were below the level.

MR. EBERSOLE: Well, I know you are overriding lots of things. Why not add another?

MR. BOUGHMAN: It would be nice to have.

MR. EBERSOLE: Thank you.

MR. KERR: Other questions?

(No response.)

MR. KERR: Thank you, Mr. Knuth. Any other general questions? Someone is going to explain to me how the utilities group reached its criteria for determining that things were okay.

MR. WARD: I have one other. Are we going to have a seminar on the Wurgassen effect, or whatever it was?

MR. KERR: Today?

MR. WARD: Maybe it has to be only a one-sentence seminar.

MR. KERR: Do you want someone to tell you what it is?

MR. WARD: That's it, yes.

MR. EPLER: The what?

MR. DITTO: Can you spell it?

MR. KERR: Mr. Knuth, would you give Mr. Ward a brief explanation of the Wurgassen effect, the effect that has to do with the quencher?

MR. KNUTH: Yes, the effect they had in a German reactor when they were depressurizing the pressure relief valves, when they were depressurizing, or they had a safety relief valve which was stuck open, and they heated up to cool, and they reached a condition of unstable steam quenching where the safety relief valves were discharging into the pool, and they got some fairly heavy vibratory loads, which was due to steam stability quenching, which caused buckling of the plates in the suppression pool.

As a result of that, there was a fairly extensive R&D program to put either T quenchers or the various types of quenchers at the discharge point so that you could maintain a margin like ten degrees of subcooling, that you do not get this instability or this chugging effect or vibratory motion that could be potentially destructive. Since they have installed those quenchers on all plants, I don't believe they have ever noted a pressure increase more than one or two psi as a result of steam discharge.

It is called the Wurgassen effect because of the name of the German reactor.

MR. WARD: Thank you.

MR. EBERSOLE: Before you get away, related to this is, you are going to 285. How are you assured that there are not local temperatures in the vicinity of the dequenchers that will essentially cause suppression bypass?

MR. KNUTH: Again, we have looked at the data in the NUREG documents that the NRC has published, and during blowdown of steam through the relief valves, and we have looked at the temperature distributions on test data.

MR. EBERSOLE: Do you mean around the quenchers?

MR. KNUTH: No, around the pool.

MR. EBERSOLE: I am talking about around the quenchers themselves, close to the quenchers. How do you know you won't get suppression bypass in the local region of the quenchers? You don't really get out in the pool.

MR. KNUTH: As I said, the reason they ran the test was to establish how much of a margin local subcooling you need, and the value that I have talked about doing an analysis, the requirement of GE is ten degrees.

MR. EBERSOLE: I guess the question is, are you sure you will get it locally?

MR. KNUTH: Well, you never prove a negative, but the calculations show you do not have, as long as you have that margin, you are okay.

MR. EBERSOLE: Right, but that is the homogeneous.

MR. KNUTH: Yes.

MR. KERR: You are asking this question, and it is a perfectly reasonable question, but in the context of the earlier statement, they are not taking credit for that being successful.

MR. KNUTH: Any longer.

MR. KERR: Any longer. All right.

Any questions?

(No response.)

MR. KERR: Mr. Page?

MR. PAGE: Thank you.

To respond to your question, Dr. Kerr, and to summarize, I am going to, let's say, shoot from the hip, but very carefully, to be presumptuous enough to say we have now arrived with a very solid basis for a safety goal, when everyone else is struggling around, I will not do. I will tell you what I feel to be a mixture of consensus and my personal opinion, I suppose, as to how we arrived at the fact that what we are proposing in terms of an ATWS fix is, we think, proper and sufficient.

It is true that most of us in the industry, I think, feel that the ATWS risk to start off with is quite low. Now, "quite low," let's just say that means lower than the NRC staff thinks it is, namely, because we feel the scram failure rate is somewhat lower. As Mr. Bernero described it, we have assumed, and are willing to live with the scram failure rate arrived at by the collegiate opinion of the NRC and developed extensively in their report, NUREG-0460.

The fact that we are willing to do that, I think it would be fair to say, we feel such an assumption is conservative, but not a disaster, not completely out of the realm of reality, but we do feel it is conservative. We start with that. Then we feel that the fixes we have proposed have several merits. One is, they are relatively simplistic, well thought out, and easy to handle. We have a great fear, and particularly our vice president of operations, of going in and monkeying around with plants built and doing extensive changes. I have some background in FERMI I, and that is how we got in trouble there.

Most of the fixes incorporated in the utility proposal, I think, can be described as fairly straightforward. I think it is also connected to the fact that they are cost effective. The reason they are cost effective is, I think, the rather obvious principle. I don't mean to be talking down to you here, but I like to sort of put it into perspective. The first hump you take out, the first reduction, the first factors of improvement in risk are the most cost-effective, even of all subsequent orders of reduction cost the same amount in dollars. That first group of three or four or ten, whatever it is, is the most important.

Our subsequent factors after that have less and less benefit, because the absolute risk you are dealing with becomes less and less, so that is one of the attractive features, I think, with going with what you might call a modest, cost-effective, simplistic approach to trying to fix the problem. We do want to fix it. Some plants already do have some ATWS mitigation equipment on it that is not prescribed. The NRC sometimes has ARI. Some plants have ordered it. Some plants are looking around and doing engineering evaluations on increased boron injection. Some are not. These are plant-dependent decisions. Everyone doesn't feel exactly the same.

Again, this is a rough try at a consensus opinion, but if we do reduce this ATWS risk, if we start by assuming the staff scram failure rate by several factors or, according to our latest number, down to 1.6 x 10^{-5}, which is down about where Mr. Bernero's presentation showed we got in the case of boiling water reactors, I am speaking of now, about where we got with an 86 GPM manually operated system. That is about where we are now with 43 GPM, but taking some credit for these EPG's. That is credit we can handle a turbine trip with bypass, but we cannot handle limiting MSIV events as were just discussed here.

So, you are talking about several factors. In fact, it is almost a factor of ten now. We feel that you are indeed down in the area of a residual risk that indeed places ATWS on a comparable level of most of the other risk contributors, whereas before in some cases it was a dominant contributor, and we feel it is appropriate, first of all now, to handle this as a residual risk in the severe accident rulemaking along with the other ones.

We also feel, even though we didn't arrive at it so elegantly, that perhaps it is consistent with a rough safety goal, as Mr. Bernero has described. It is sort of down in there where we talked about safety goals before. We have proposed safety goals, and indeed it seems like it is in down in that 10 percent rough region of suggested safety goals. So, we feel a simplistic approach, a cost-effective one, has taken what we feel to be a conservative ATWS risk to start with, and it reduces enough to get it down to where it is a residual risk comparable to all the other risks, and indeed, consistent with what is being talked about by most people for a safety goal.

Now, I think the only other thing I would like to add is that, and on this one I have a few notes to help me out, we do recognize that arriving at all of these numbers, there are a lot of uncertainties, and a number of them have been talked about already. We also feel our approach in evaluating the improved or the reduction in risk by our fixes, a number of conservative assumptions have come in there which we think have amply balanced out some of the uncertainties in the calculations in the first place.

I have made a list of these. I don't think I will read them all. I had a list of seven. One of the reasons I will just mention some of them briefly is that

Mr. Bernero touched on three right away. Those were, the ratio of electrical to mechanical failure, we think, is on the conservative side. It is on the safe side, because even if it is not conservative, it is not very unconservative, or it could be very conservative if it went the other way.

He talked about, and I think this is a very important one, the idea of using defined limiting parameters which are conservative to define a full-blown ATWS accident, because you see, what we have done here, at least in the case of the boiler, for example, we say 200 degrees torus temperature, bam, $10 billion. So there are a lot of uncertainties about what the specific ATWS consequences might be and the health effects off-site, plant by plant by plant, and indeed perhaps a real exact analysis would make us feel better, but instead we have used the conservative approach of defining what a real full-blown ATWS is in lieu of going the other direction.

I am just repeating what Mr. Bernero said, and I think that is a good approach, but I think it is still conservative.

I think I will just mention one final conservatism that we have applied. I don't think it has come up here today. I think in the real world most

ATWS's or most scram failures that would lead to an ATWS probably would be partial scram failures, and all of our analyses, and in all of the staff's analyses, all scram failures have been assumed to be total failures, and I do think the engineering judgment would predict many of these would be partial failures, which would be easier to mitigate. Particularly in the case of a mechanical failure, you are more than likely to have a partial failure as opposed to the full scram failure. This was discussed at some length by the staff in Appendix 2 of NUREG-0460.

I won't read the whole section, but I will quote a summary of the portion dealing with the mechanical section, where they say, "The probabilities of common mode failure involving, say, 100 rods is intuitively less probable than, say, ten rods, but no quantitative model seems to be both presently available and believable."

Thus, both the staff and the utility group in this case say every scram failure is a full-blown scram failure, because we can't prove otherwise, but I think most engineering judgment says that is not the case. So, that is just one of several assumptions we feel back up or we feel make our reduction in risks credible, starting from a base we think is somewhat conservative to start with, and putting the risk down to where we think it seems consistent with safety goals and comparable to the kind of risk levels that have indeed been calculated by current state of the art PRA methods for other risk contributors, and that is sort of the basis of where we are coming from.

I have stumbled around a little bit here, but if some of that is not clear, I would be willing to clarify it to the best of my ability.

MR. KERR: I just wanted to get some idea. I constantly saw in the utility group report the comment that things were already safe enough, and I assume that you did not rely upon the NRC for that sort of judgment, since you disagree with them on other things, and I think the safety of the plant is, after all, the responsibility of the operator, and I was just curious as to how one reaches -- what process is used, whether you use PRA, PRA and judgment. If you use PRA, at what level and with what sort of confidence? Anything you can tell me about the decision process.

MR. PAGE: I think what I said roughly, if it was rational sounding, was, it is sort of the kind of way we as a group came to the conclusion of what we are looking for and how safe is safe enough with regard to ATWS. There is an entire spectrum of what they think the real risk of ATWS is. I know of one case where a very competent engineer and former operator, who is very concerned about the safety of his plant, is heavily involved in the safety review of our plant following the Three Mile Island accident, and as a result of that came up with several fixes never mandated by the NRC, because he felt he had to protect the investment and protect his plant, and I don't care if the NRC doesn't want it, we will fix this thing, but he would never look at ATWS, because he felt that was not the real world.

So that is one end of the spectrum, not because he wasn't concerned about safety, but just his feeling maybe because he knows about the care of the design going into the scram system and all of this stuff. I don't know. He is not a PRA believer. That is his gut engineering feeling. That is hard to document in any believable way. There are other equally competent people, some of whom are on the NRC staff, who feel that several orders of magnitude higher represents the appropriate risk for ATWS.

MR. KERR: I was also concerned because the group includes people who have a variety of plants, and one set of that variety is willing or at least was, I don't know whether their position has changed now, to depend upon the lifting of a head gasket and relieving pressure through that mechanism. I guess I have not done a lot of practical engineering, so I don't know how head gaskets behave and bolts pull apart, but I believe if I were responsible for a large plant, I would have some misgivings about that method of pressure relief.

It seems to me the uncertainty in even that sort of conclusion, and it may not be one now held, is different than some of the other uncertainties, so I was just trying to get a feeling for how the various people on the group concluded that yes, my plant is okay now, it is safe enough.

MR. PAGE: When I said I was responding the best I could as to the consensus of the group, I was biased by my own feeling. The latter part you must recognize has to do with the fact that I belong to a utility that has one reactor down Would you or anyone like to comment on Dr. Kerr's question?

MR. HOUGHTON: This is Tom Houghton. I am not with a utility, and I don't think we have a Combustion Engineering --

MR. KERR: I was only using that as an example of what appears to me to be a spectrum of situations all of which are apparently embraced in the document I read which said things are okay. And I was just trying to understand what set of criteria were used by the group or individuals in reaching that conclusion. There is a lot of talent in this group, and I thought I would learn something.

MR. HOUGHTON: I would just make a comment about the Combustion Engineering report, that I don't believe the members of our group felt that the head lift was a viable thing or something they would want to see happen in their plant, that they were relying on that to save them from the consequences of an ATWS. I think it was used in the vendor's report. It was used in our PRA when the question was raised about that, and we looked at it again. We looked and talked to our technical consultant on PRA, and said, suppose you took out that head lift, and he showed us the numbers would not be appreciably different, and I think we probably should not have put that in our study. It created the impression that we thought this was really a viable way to survive ATWS, whereas I think the utility's position or feeling is that the total likelihood is low such that they don't consider additional relief valves as a needed improvement to protect them from the low possibility of that event occurring.

MR. KERR: Mr. Bernero, did you want to comment?

MR. BERNERO: Yes, I would like to add a couple of comments to what has just been said about success criteria and decision criteria. If you are choosing to pursue in a risk analysis sense the real event of full-scale core melt, a full-scale release with severe off-site consequences, you are going to be forced in modeling to get to uncomfortable things like describing pressure vessels lifting, the flanges blowing down. How does a core really melt? Does it blow out abruptly? And so forth.

These attempts at realistic modeling are very difficult, and I think what was unsaid was, it was almost by tacit agreement, at least I perceived the utility group doing it, and we certainly did it, we said, let us not bog down in uncertainty analysis of such. Let's go back to P ATWS as a figure of merit, unacceptable plant conditions, things that are much more tractable for analysis, Service Level C. That was one of the factors that got us to Service Level C rather than going off into limbo at some higher pressure.

MR. KERR: I was really speaking to the utility group report. As I read it, Bob, I didn't have the ability to read between the lines that perhaps you had.

MR. BERNERO: The other thing is, I think it is worth saying there is a difference that you would see, at least that I perceived, in the way they presented their logic, that you should expect to see between their presentation and our presentation. We are fortunate to be at the center of theology for safety goals, so that we can state that and define it with the latest information from just down the hall, and state it in terms of both a level of protection, P ATWS insofar as it describes a given desirable level of protection, and treating an alternative benchmark, and that is what is the value impact on this next increment of change.

So, we use level of protection primarily, and alternative illumination with value impact. The utility people have argued for many years that the probability of the event is a lot lower than we say, so they have in effect been arguing the level of protection has always been acceptable. They got dragged kicking and screaming up to our level of probability, and therefore have staked out value impact analysis alone as a decision tool, and it is logical that they would.

I think it makes you a little more vulnerable to the uncertainty in the value impact.

MR. KERR: But you see, I wasn't really asking how they try to satisfy the NRC. I was trying to find out how they satisfied themselves, which I think is also fairly important, and which they have to do.

MR. BERNERO: Of course, they have the answer to that.

MR. KERR: Your comments are not really in answer to the question I was trying to get across. There was another part of the report that caused me some concern and I would like someone to comment on it if they can.

It appears to me that that spectrum of core melts that might be caused by ATWS is likely to have more serious consequences than just a common, ordinary, everyday core melt. I did not see this problem addressed in the utility group report at all. I would have felt better if I had discovered somehow it was taken into consideration in some fashion, because to set up a core melt probability as a safety goal, about which I have some concerns I must admit, and to ignore the fact, or at least what I believe to be the fact, that core melts are not all alike may be a good regulatory policy.

But I cannot see how somebody who is responsible for a power plant can be quite so cavalier about things. Do you understand the comment? I am not sure it is a question. It is something I kept looking for and did not find in the report.

MR. HOUGHTON: We had great difficulty in trying to decide what to use for our figure of merit, so to speak, and because of the uncertainty in containment failure modes and the different effects in different sites, we decided to stop short, at the core melt, just because we felt we could not go beyond that with any comparison that would mean something between plants.

MR. EBERSOLE: Bill, to follow your line of thought, isn't your feeling due to the fact that a core melt due to ATWS is always accompanied by a sink of heat in the containment that is not in their analyses?

MR. KERR: I would assume if an ATWS occurred one would get a rapid buildup in pressure and perhaps an early containment failure.

MR. EBERSOLE. Yes.

MR. KERR: If it proceeds that far and hence one is likely to get a bigger release, and if the thing proceeds more slowly, that would be my sort of naive analysis.

MR. EBERSOLE: It is ham and eggs. They go together.

MR. PAGE: Dr. Kerr, this may not be coming from the direction you want. I think, back to this assumption that I talked about earlier and Mr. Bernaro mentioned earlier too, where we used rather conservative plant parameters to define a full-blown ATWS event in a certain sense compensates for the spectrum or the fact that the ATWS core melt is like to be more damaging than an average core melt, because we are not even going to core melt.

We are actually going to other parameters an that is as far as we go. We say that is identical to core melt, to containment failure, to a full-blown ATWS, and I do not feel bad. I think that assumption is sufficiently conservative to take care of your concern.

Now, however, if you are asking how we got to that --

MR. KERR: I do not know whether it is sufficiently conservative to take care of my concern or not, and that is the reason I would have liked to have seen some comment on it in the report.

MR. PAGE: I was going to ask Dr. Burns, who is the underlying man behind our PRA study, to give you a firsthand account of how the criteria were developed.

MR. BURNS: The original criteria for the study were, of course, limited to just the frequency of unacceptable conditions or, if one would like to extend that, you could almost say that that approximates a core melt.

To address your question specifically, I guess there is a popular belief or people are around saying that ATWS core melts could potentially be of more severe consequence than other accidents. To address that specific question, first we say in PWRs that is probably not true or at least risk assessments to date have said that is probably not true.

So if we look at BWRs, which is the question that you addressed, I think, specifically, for BWRs the analyses that have been done that I have seen and that I have done, when we did Limerick, we said yes. My God, there is a difference between ATWS. There is a difference between loss of containment heat removal. There is a difference between loss of coolant makeup. There is a difference between interfacing. Gee, you ought to take that into account. You ought to find out what the consequences are for each one of those accident sequences and make sure they are included properly.

Unfortunately, the tools available to us, the codes that we have, and the understanding of phenomena in containment core melt and even ex-plant analysis are so crude that the ability to predict early fatalities, which is almost unbelieveable, I mean --

MR. KERR: I believe it.

MR. BURNS: The ability to do that is not really there. So any -- so the calculations that were done for Limerick, for example, that showed that ATWS could be a contributor to early fatalities are probably an error on the high side.

My perception of what one uses today within the tools that we have available to us are core melt frequency, latent fatalities and property damage. Those are the kinds of things that I would use. And if you use those measures of risk, then the consequences of ATWS are not different than other accident sequences.

The question of can you get rapid release of radionuclides that can cause early fatalities, that is a question that is given to so much uncertainty I do not think it is easily answerable, and that is why we did not use that as a criterion.

MR. KERR: Well, the fact that it is subject to a lot of uncertainty can lead you to a number of conclusions. If the consequences are extremely high and the uncertainty large, even in spite of that uncertainty you may want to do a good bit to avoid it and indeed perhaps it is the conclusion of the group that a great deal has been done to avoid it.

I was just puzzled that in the light of the sort of comments you are making that the issue was not even mentioned in the report, because it does seem to me it is an issue. It may be an issue with which one can deal and perhaps the conclusions reached by the report are precisely the conclusions that would have been reached had it been dealt with and discussed in some detail.

I was just puzzled. I did not find any mention of it.

MR. BURNS: In order to do justice to an analysis of that nature, you really are bound to do some sort of site-specific analysis and incorporate other accidents into your analysis.

MR. KERR: I agree with you wholeheartedly, but any operator of a plant who is operating a plant on a site where he has to worry about the people living in the vicinity and hence when he reaches a conclusion, he had better have taken all of these things into account. And if you are advising that operator and do not tell him that these things are important, it seems to me you may not be giving him the complete story.

MR. BURNS: I can assure the complete story was given to the utility group.

MR. KERR: All right. Are there any other questions?

(No response.)

MR. KERR: Well, let me thank all of you for what to me at least has been a very helpful presentation and the patient and elaborate response to questions you have given.

I want to spend a few minutes with the consultants and Subcommittee members in getting some advice on how I should report current progress to the ACRS. Does anyone have any further questions of either the Staff or the people who have participated in the presentation? Any further questions, Mr. Ward?

MR. WARD: Yes, I have one of the Staff.

In the original safety goal, as presented several months ago, there was, of course, a number inteded to express a guide as to some acceptable probability of frequency of core melt and then the original application plan, which came up in the summer.

To the extent I understood it, that particular numerical value with a guide was the one that was really going to be used in the actual plan. The frequency of core melt was the so-called safety guide, and that was the definition of the PRA that would qualify as showing conformance with the safety guide -- the safety goal.

Now I think this Committee expressed a problem with that and said if you are going to do that sort of thing there needs to be a comparable number in the goal which is something expressing the reliability or probability of failure of containment function. And I am not at the center of theology, so I do not know where you are with that.

Maybe someone is coming up with a number on that, but the retort at the time was that that was awfully tough to do. But the basis for your developing an ATWS guidance here which is in conformance with the overall safety goal is that you have come up with such a number. You used the ATWS sends the challenge more than perhaps other sequences. You have tuned in to that, but you have come up with a number.

How come? I mean, how come you can have a number for the ATWS when we have not had one for the applicatic he more general safety goals?

MR. BERNERO: It is all done with trickery.

MR. DITTO: Mirrors.

MR. BERNERO: Two issues. First of all, let me just reiterate a point I made during the presentation, that with levels of risk chosen as they are chosen in safety goals, we are describing a distribution of our understanding around the level of risk and we are not dealing with a threshold of acceptability, a speed limit that we must be sure we are below.

You would see that reflected in the draft implementation plan that came under great fire in that the 10^{-4} core melt is embraced also by a 10^{-3}

operating limit, which says ALARA prevails, ALARA considerations prevail around the goal limit. And when I get a factor of ten above it, I will start worrying about fixing things on level of safety. So as long as you keep that in mind for the performance standard that is selected by whichever means, it is not a rigid speed limit.

Secondly, the argument we have had with the ACRS on the containment performance standard, whether or not it is appropriate for a safety goal here, does not hinge on whether or not the Staff feels we can calculate the numbers Dr. Burns was just talking about. We do it, but we do it with the MARCH code and with the MATADOR code or CORRAL code prior to the use of MATADOR, which is not published yet. We are doing it with codes filled with uncertainties, that are crude, and we are talking alternative scenarios where in some cases core melt precedes containment failure. In other cases, the containment failure is believed to lead to the core melt.

We can calculate the number all right, but we are asking ourselves if it is worth calculating it as a separate enterprise in this regime, in this trial period. What we have done here with ATWS, we have said there are in the safety goals two criteria that are pertinent to this energetic core melt called ATWS. One is the full-scale core melt criterion and the other is the early fatality criterion, which would be limiting, we are quite sure.

We do address the containment performance variability. It is in those fractions. The fraction Y embraces it. We just do not think it is worth trying to set a good generic value for the containment failure probability under ATWS, given there is a large-scale core melt. I am much more interested in knowing what is the range of containment failure probability that I might find so that I can go back and have my figure of merit, PATWS, intelligently selected.

It is just an example of where there is not now a sound need for having a containment performance goal, as such, because I will not use it. I will not base an ATWS regulatory decision on the containment performance goal. I am taking containments as they stand and the range of variability and I am trying to make a regulatory decision with PATWS a much simpler, more credible figure of merit.

So it is not a matter of we just learned yesterday how to calculate the containment performance. It was done in WASH-1400, but is it worthwhile using it as a figure of merit now on a regular basis the way we would use the possibility of a full-scale core melt, and we do not think it is. That is the essence of our difference.

MR. KERR: Are there other questions?

(No response.)

MR. KERR: Then I would welcome any additional comments from Mr. Epler and Mr. Ebersole and I would welcome comments from the others of you who want to comment on points that you think are important in the Committee's consideration.

What I propose to do is make about a twenty or thirty minute report to the Committee at our next meeting. I would assume from the schedule that Mr. Bernaro showed us that this does not go to CRGR until December 15 at the earliest and my guess is the Committee will want to review it. Did I miss something?

MR. BERNERO: I think you misstated. We are briefing the CRGR on November 3. Our schedule to give them the Commission paper for approval by November 10, and presuming that they approve it or iterate it in some way, we will go to the Commission by December 15.

MR. KERR: All right. So it probably makes some sense for us to schedule a Committee consideration of this at the December meeting.

MR. BERNERO: Yes, that was my idea.

MR. KERR: All right.

MR. EBERSOLE: Bill, I will just express kind of a gnawing sensation I have or a sensation of need. We have seen the front edge of ATWS, the Brown's Ferry scram dump volume failure. We learned about the voltage variation problem at Grand Gulf, causing sixteen-odd solenoid valves to stick. I have read but have not examined some incidents at Big Rock Point.

But all of these incidents put together seem to me to say that at least I have never seen what I would call a grinding, detailed, comprehensive search for the elements of common mode failure of these systems. I have only heard statements to the effect that they have been considered to this degree and that degree without a grinding physical search to see where they are in the context of service variations, environmental effects and a lot of other things which are the domain of common mode failures.

Such material may be available, but I do not know where it is, and I would like to see that that sort of thing has in fact been done thoroughly to get at the elements of common mode failure and express them in a documented form.

MR. KERR: Mr. Ward?

MR. WARD: I guess, strangely enough, I remain a little bit uncomfortable with the Staff's proposal for, of all things, the Westinghouse plants. This problem started out as a what-if question. What if the safety rods do not go in? And the obvious response to that would be to figure out some other way to push in the safety rods or something equivalent.

The solutions that it looks like the Staff will be satisfied with, except for the Westinghouse reactors, all entail something additional to get the safety rods in. The argument for this not being required in the Westinghouse plants is, I guess, a good one, but it is entirely incomplete and probabilistic, and I think this is probably the first, if this becomes a regulatory decision or whatever it is going to become, may be the first decision that is entirely based upon probabilistic analysis.

MR. KERR: Well, I guess one of us misunderstands the Westinghouse situation and it may be me. My impression was the decision on Westinghouse was perhaps the most deterministic of the decisions, that Westinghouse has a system that ride out an ATWS independently of whether the rods are in, except in something like one percent of the cases, when the MTC is too low.

Now in that sense there is a probabilistic decision being made. But otherwise, the relief capacity of the combined PORVs and safeties and the moderator temperature coefficient is such that an ATWS does not get one above service level C, I believe. At least that is my understanding.

MR. BERNERO: Yes, that is right.

MR. WARD: Maybe that it is and it is a fairly simple probabilistic argument in answer to what you are saying.

MR. KERR: At least from my point of view it is a somewhat less complicated one than some of the others.

MR. WARD: All right.

MR. KERR: Other comments? I need advice, gentlemen, help, suggestions.

MR. EPLER: Yes. I would like to comment.

At the time the ATWS issue was first considered, there was no safety objective and it was first expressed in WASH-1270 as 10^{-6}. This was consistent with a panel discussion in Washington of the NS about 1970, and for each individual contributor for ATWS, the probability would be 10^{-7}.

I think over the years it has become obvious that this is not only undemonstrable but is unrealistic. There is no such thing as 10^{-7} in this world. Now we have a more realistic conjecture of 10^{-4} and our belief that the ATWS probability is not too far from that, so that any marked improvement would be quite welcome and quite useful.

Now today I have seen an enormous amount of energy proposed for the operator and this is rather staggering. We expect to see 33,000 scrams on a BWR and one of those will fail. We are going to train thousands of operators to be alerted for that one event, and each individual operator will say I cannot be much concerned because there is only one chance in ten during my career in the control room when this occurs, and, therefore, only one chance in 330,000 I will have to do anything and there are two other guys in the control room.

MR. KERR: I hope this word does not get to operators.

MR. EPLER: Well, if they are bright, they will understand this. With two other guys in the control room and only one chance in 330,000 I will have to push the button, it ain't my problem. So I would rather see all of this operator activity not devoted in mitigating this one event -- this never-never event.

I would like to see this activity devoted to preventing the transients in the first place and making the utility some dough. It costs $.5 million to scram. They ought to be motivated to prevent this scram and prove that they did it.

Now a factor of two is not much in reducing risk. It would be useful in this case because the ATWS probability is so very close to the safety goal that a factor of two would be significant. A factor of three or five would be a little better, but a factor of two in 33,000 scrams costing $.5 million apiece is a great deal of money and would support a great deal of activity and there would not be much question about the cost-effectiveness of it.

I have not heard any discussion of this and I feel that this whole thing has become completely lopsided. We realize that the NRC very properly cannot give credit for operator actions or non-safety grade systems during the course of this kind of an emergency when premium high grade systems have failed and there is a great deal of stress.

You cannot expect an operator to behave properly. But when the plant is going along under normal conditions and everything is in predictable shape -- no fire, no smoke, no running around screaming -- then is when you can count on the operator to perform predictably in preventing transients, and we are neglecting it and I think this thing is a little bit out of hand.

MR. EPLER: I think we have an opportunity here. Since we don't have an agreed ATWS remedy, I think here is an opportunity for the utilities to step in and say, we would like to have a crack at this. I wish they had the whatever it takes to do that.

MR. KERR: It's hard to disagree with the desirability of decreasing transients, and that would certainly be a great method of eliminating ATWS.

MR. EPLER: This is an opportunity for that to occur, but I see no leadership.

MR. PAGE: Is it appropriate to comment after hours?

MR. KERR: If the comments are cogent, relevant and succinct.

MR. BERNERO: And he will rate you on it.

MR. PAGE: Very briefly, I think some of what you are asking for is one of the tasks we have put our newly assigned STA's to. We call it improved reliability of the plant. But hopefully, there will be someone in the control room to give advice on accidents.

They will be watching the kinds of things most people wouldn't take the time to do because they're too busy doing other things to try to improve reliability. And I think that is somewhat connected with also reducing the number of scrams. How successful it will be, I don't know, but that is the plan.

MR. KERR: Any other comments? Mr. Lee?

MR. LEE: I still have concerns for relying heavily on probabilistic risk analysis in resolving the ATWS issue. I believe this is a useful technique to provide some information as a barometer and perhaps to give us some guidance as to relative risk of various transients and sensitivity to various parameters and things like that.

Somewhere along, we will still have to rely upon engineering judgments, even in probabilistic risk assessments. I believe engineering judgment does come in a lot, and in this regard I have a couple of examples where I have a great deal of concern.

The first item is related to overpressurization in BWR's in CE and B&W reactors. Instead of allowing the lifting and so on, I believe the NRC's Staff position is that you let them use 50 percent moderator value of temperature coefficient, I believe. If I understand your present position correctly, you may let them use a 50 percent value moderator temperature coefficient. Am I wrong?

MR. BERNERO: I would say it a different way. We would say 50 percent of the time the moderator temperature is such that pressure peak won't exceed service level C. That is a success. 50 percent of the time it will exceed service level C. That's failure.

MR. LEE: I have difficulty in treating moderator temperature coefficient on a purely probabilistic basis. For reactor cores, if the particular fuel loading is there you can't do a thing about changing the moderator temperature coefficient, and you cannot count on the reliability of having a certain favorable value of moderator temperature coefficient there. You have to do something about it, rather than applying probabilistic methods strictly.

That is my feeling, and in the same way the main steam isolation valve closure event, that lies in the boundary. Somewhere along one has to exercise engineering judgment and say, maybe we have to do something about it if it can lead to temperatures in the suppression pool up to 260 degrees or whatever. Maybe we should do something about it.

And the third item related there is the limit cycle on the oscillating behavior I have seen in the General Electric report referred to earlier, I believe. And the latest information is maybe we don't have any oscillations. I would like to see more information on that. I have seen fairly recent tests performed on overseas BWR's where they did observe oscillation at fairly high power, in fact.

And the third comment I have is again related to moderator temperature coefficient. I believe PWR manufacturers and the owners very much would like to go to improving moderator temperature coefficients, not just for the purpose of ATWS resolution but perhaps to buy more maneuverability in their fuel cycle. I don't think it would cost so much money and so much actual down time to incorporate different designs to gain a substantial amount in the moderator temperature coefficient early in life, where you can indeed possibly run into overpressurization transient.

Those are my three comments, I believe, or two and a half or whatever.

MR. KERR: Thank you.

Walt?

MR. LIPINSKI: The utility group had a good point with respect to MSIV closure and BWR's. If you look at the table they have on page 3-7, there is a ratio of 20 to one between turbine trips and MSIV closures. Where the data comes from, I don't know. If it is true, I think they have a point of argument, and not including the MSIV to meet the 200-degree pool temperature, for example, for the 25 to 110 percent power case in subsequent years after the first.

They are showing .13. That is, an average of about every eight years they expect an MSIV closure. How that number was derived, I don't know. But assuming it was true and you have a ratio of 20 to one, I think they have a good case of saying the MSIV's are beyond the ATWS target numbers.

And the ratio of electrical versus mechanical failures has been arbitrarily taken, two to one, and I don't think that is the proper number to be used for BWR's. If you look at the way the systems are made up and what must function in the BWR to get scrams, it's not fair to lump the PWR and BWR systems into the same ratio.

MR. KERR: I'm sorry. Do you think two to one is okay for BWR's, but it's too small for PWR's?

MR. LIPINSKI: I think it would probably be more like ten to one, ten mechanical failures to one electrical failure for the BWR, if you were to sit down and do a part count and look and see how many pieces had to function.

MR. KERR: We are talking now about feedwater to scram, not failure of a part of the rod drive.

MR. LIPINSKI: But the 5 times 10^{-5} has been apportioned on the ratio of two-thirds to one-third to put it into whether it's an electrical failure or a mechanical failure.

MR. KERR: But it's a failure that causes failure to scram.

MR. LIPINSKI: Right.

MR. KERR: Not the failure of one rod drive, say.

MR. LIPINSKI: No, no. It's a question of how many rods go in to say you have not had sufficient rod insertion to cause scram. But if you look at the physical makeup -- take the Westinghouse system. Open up one of two breakers and you cut the power to all of those drives, and those roller nuts open and the rods go in.

The other one is on the argument that was offered with respect to the BWR operating procedure in using a number of .16 of probability of failure that the procedure will be executed. I don't think that is the right number, considering the stress involved based upon the other data we looked at. And I don't know what the Staff's opinion is on it.

Based on where their upper limit curve was, I think it is a stressful situation. I don't think it's anything close to being an intermediate situation.

MR. KERR: My interpretation of the Staff position was that they did not consider that.

MR. BERNERO: If I could clarify. We supported the research that developed those curves, but please don't call it the Staff curve.

(Laughter.)

MR. BERNERO: They are a model for that. We did not attach hard significance to that. That was a very complex but significant factor in our evaluation of the émergency procedure guidelines, the stress level, and in fact it is one of the principal factors leading to the doubling of the boron injection capability choice to make up for doubts about time, doubts about operator error or operator success in a given time, and doubts about pool temperature.

MR. LIPINSKI: I'm pleased to see they're working on procedures and I wouldn't want to discourage it. I will relate my experience when we visited the Sequoyah -- well, TVA -- simulators about three years ago. Dr. Catton and I went in there and we went into the Sequoyah simulator first. We asked -- there were two operators at the console and we asked the trainer to inject a turbine trip with failure to scram.

The guy at the console didn't know what was coming. He proceeded to have that plant sitting at 100 percent power. He threw in the transient and immediately the operators noted the rods weren't in.

They proceeded to inject boric acid. The transient was over.

We walked over to the Browns Ferry simulator and we asked the trainer at the console to do the same. He said he didn't even have a switch to prevent the rods from inserting and that console was not equipped to put in an ATWS.

I am pleased to see that the utilities are moving in that direction. They are actually thinking about an ATWS in a PWR.

MR. KERR: Thank you.

MR. KNUTH: I would like to comment, if I could, on the stressful situation. I have experienced stressful situations, not in a control room but in an aircraft, having a few thousand hours as a pilot. And one time I experienced a rather stressful situation when an engine caught fire and we didn't have a fire extinguishing system on that particular aircraft.

I think in that particular event -- and I have talked to operators about this -- the stress doesn't occur until a few hours later. You go through a trained procedure, whatever that is, and you really don't realize how stressful or how hairy it was until you set down, you are on the ground and you are walking around. That is when the stress hits you.

I have talked to operators that have experienced events, and I kind of wonder the difference. I think the curves that are shown are those for which a person is trained and those for which there is no expectation or knowledge of what is going to happen.

I think what we are trying to do in the utility group is train people to understand, to follow procedures that are established, to react to a situation. As I say, we are using mid-figures from an event where there are no established procedures, no training. I think we are probably on the wrong side. We should probably be taking more credit than we are.

MR. KERR: You know, you may get in trouble. You may convince these operators that an ATWS is possible, and then they will want to fix the plant up so it's less likely.

Mr. Ditto?

MR. DITTO: I have a little bit of concern about the PRA. Every time we hear a PRA discussion somebody says, well, we're not really concerned about the absolute numbers, we think we've got good relative numbers. And yet, when the two sides begin to converge on a number, the absolute value vecomes important.

And I think the results we hear now are kind of fuzzy. There were three examples given today that I noted. One was, we're using the best available data. That doesn't say anything about how good it is. We've got a saying, the best we've got is none too good, and I'm afraid the data on our shutdown systems is like that.

We are talking about generic plants versus specific, and we are still doing our analyses on plants described on pieces of paper, and I wonder how much information relative to the real plant gets into the calculation. As you know, the plants and how they are operated, the individual plants will probably have a lot more variance among them than the difference between a generic plant and a specific plant on paper.

Then we hear about the best available techniques for handling human factors, and human factors are very difficult to handle and we know that, so the best available techniques and models leave me a little concerned about the numbers we come out with.

And the last one is, how do we handle common mode failures, our modeling for common mode failures. We just don't know quite how to handle those. And so this leaves me concerned with the absolute numbers. Now, if you tell me we have relative numbers, which are all that's important, then let's please not make decisions based upon bringing these two numbers into convergence, as they seem to be coming right now.

MR. KERR: Having said all of that, do you have any comments on the Staff's proposal for resolving ATWS?

MR. DITTO: Not right now.

MR. KERR: All right. Mr. Moeller?

MR. MOELLER: I have been troubled throughout this whole thing by uncertainties. We ran off a litany of uncertainties this morning. From the utility group standpoint, I guess I see the pro side of the assessment, that it was apparently a very good PRA-type analysis.

The NRC basically endorsed at least the risk numbers that came out of it and, if you will, used it as a springboard upon which to generate their own suggestions. There is apparently an awful lot of good work that has gone into developing these emergency procedure guidelines, although I guess it's not obvious to me whether it obviates the need for an automatic, at least in the case of the BWR, an automatic SLCS.

One of the things that really wasn't brought up, I believe, at least in the initial utility group response they had some kind of exemption clause where, if they could prove that the risk was not high enough, that particular plant would be exempted. That sounds great in theory. I don't know that that is actually --

MR. KERR: The Staff didn't take that seriously when they wrote it, I am sure.

MR. MOELLER: All right.

On the con side, again it's the uncertainties. The numbers are just plain spongy and I don't know what to do about it. It bothers me, too, that we keep saying how spongy they are and how we don't believe the absolute numbers, but when push comes to shove we are actually tieing our recommendations to a 10^{-5}, because they're above and we go one step further.

The NRC -- well, I guess both decisions have a pro side that it is a pragmatic issue, let's get it done; we can study anything to death. The negative side of the NRC position, again it's the exemption type thing. When is a plant "safe"? They are still burdened by the same generic fixes.

But again, we get into the performance versus prescription. If one has to prove performance, it seems to be just an endless battle. It appears the numbers talked about in going from the -- and again, I will limit my comments to the BWR -- from the utility group position to the NRC position are low in the relative scheme of things. And while this is certainly -- if I had to make a decision with the available information, and I am not happy with it, I am not comfortable with it, but if I had to, if this would end the issue, to go with the Staff position, then I would support that.

MR. KERR: Thank you.

Any other comments? Mr. Davis?

MR. DAVIS: You either overlooked me or you're saving the best for last. I prefer to believe the latter.

(Laughter.)

MR. DAVIS: One thing I didn't hear considered that seems to me to be maybe something worth looking at, given that the power level that the plant stabilizes at is a function of the high pressure injection flow rate -- and it certainly seems to be -- and that flow rate is well in excess of that that would be required to remove decay heat or protect the core during small break accidents, would it make sense to reduce the nominal flow rate of those systems such that the core power level will stabilize at some value below the turbine bypass capability and at some value that allows a substantial time for standby liquid control, because the suppression pool temperature will increase at a much lower rate?

I say this, recognizing that for the BWR-6, for example, the core power stabilizes at only 12 percent and there is substantial time before the suppression pool temperature gets to any alarming temperature. I may be missing something. There may be another reason why these systems have such high capacity.

But it seems to me that if you could retain the capacity but set the nominal flow rate at some lower value, then you don't have to depend upon the operator to control the liquid level during the accident, at least not for some time.

MR. KERR: I want to make note of the fact that this represents a first for me. It's the first time I have ever heard anyone recommend reducing the flow rate of an ECCS system, and I just think that is significant.

MR. DAVIS: They do it anyway during this accident.

MR. KERR: I am not disagreeing with it. I have been on the Committee a long time and I have never heard anyone suggest it before. So it's innovative.

MR. EBERSOLE: But it was put there to cope with whatever a small break accident is.

MR. DAVIS: You have plenty of margin, and I think now we know better.

MR. KERR: It was really put there to cope with a large break, probably. But continue. You said I saved you for the last.

MR. DAVIS: Well, I guess that really ends my point. But if the core does stabilize at 30 percent, that means you have approximately 30 times the amount of flow you need to remove decay heat, which seems to me to be far in excess of the requirement.

I think my other comments on the relative merits of the two rules are in the other letter I sent you previously and I don't think it's necessary to go over that again since I haven't heard anything to change my mind.

MR. KERR: Thank you, gentlemen.

I would ask the consultants to give a little bit of additional consideration to this and to try to get a letter to Mr. Baynard in time for the next ACRS meeting, so that I will have your comments if you have any additional comments.

MR. LEE: When is our next meeting?

MR. KERR: The meeting at which we will consider this begins on the 4th of November.

MR. LEE: 4th of November.

MR. KERR: I thank all of you again.

Meeting is adjourned.

(Whereupon, at 5:50 p.m., the meeting was adjourned.)

* * *

NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

____

in the matter of: ACRS/Subcommittee on Anticipated Transients Without SCRAM

Date of Proceeding: October 22, 1982

Docket Number: ____________

Place of Proceeding: Washington, D. C.

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

Sharon Filipour

Official Reporter (Typed)

Sharon Filipour

Official Reporter (Signature)

Bernero (1)

BRIEFING

ALTERNATIVES

REGARDING ATWS RULEMAKING

ROBERT M. BERNERO
OFFICE OF NUCLEAR REGULATORY RESEARCH

ATWS

- ANTICIPATED TRANSIENTS WITHOUT SCRAM
- PLANT UPSET TRIGGERS SHUTDOWN
- SHUTDOWN SYSTEM FAILS TO INSERT RODS
    - COMMON FAILURE OF SWITCHGEAR
    - BLOCKAGE OF SHARED DISCHARGE PIPING
- NUCLEAR FISSION PROCESS CONTINUES
    - MORE THAN DECAY HEAT ENERGY
    - RELIANCE ON SECONDARY SHUTDOWN MECHANISMS

CHRONOLOGY OF ATWS

ATWS RAISED AS ISSUE; ACRS REQUESTED STUDY ON CMF OF RPS	1960's
FIRST NSSS VENDOR REPORTS	1970 - 1971
AEC STAFF ISSUED WASH-1270	1973
WASH-1400 EVALUATED ATWS RISK TO PLANT	1975
REVISED NSSS VENDOR REPORTS	1976
NUREG-0460, VOL 1 & 2	1978
NUREG-0460, VOL 3; REQUESTED EARLY VERIFICATION REPORTS FROM NSSS VENDORS	1979
NUREG-0460, VOL 4; REQUIRED IMPLEMENTATION OF ALTERNATIVE 4A	1980
FRN ON STAFF, HENDRIE AND UTILITY ALTERNATIVE RULES	1981

COMPARISON OF ALTERNATIVE RULES

	STAFF	HENDRIE	UTILITY GROUP
ANALYSES REQUIRED	MEET ACCEPTABLE PERFORMANCE CRITERIA ON ATWS ACCIDENT.	INCORPORATE A RELIABILITY PROGRAM.	NONE PROPOSED. BASED ON A PRA PERFORMED.
DIVERSE SCRAM SYSTEM	MOST LIKELY REQUIRED; FOR PLANTS AFTER 1969.	MOST LIKELY REQUIRED.	AFFECTS MOST PLANTS.
OTHER REQUIREMENTS	- SCRAM DISCHARGE VOLUME FIX FOR BWR'S - AUTOSTART MITIGATING FEATURES	- SCRAM DISCHARGE VOLUME FIX FOR BWR'S - AUTOSTART MITIGATING FEATURES	- SCRAM DISCHARGE VOLUME FIX FOR BWR'S - AUTOSTART MITIGATING FEATURES

ATWS RULE

SUMMARY OF COMMENTS RECEIVED

(39 TOTAL)

UTILITY PETITION	HENDRIE RULE	STAFF RULE	NO RULE	OTHER
11	6	1	18	3

	UTILITY	HENDRIE	STAFF	NO RULE	OTHER	TOTAL
UTILITIES:	10	5		14	2	31
PRIVATE CITIZENS:			1		1	2
REACTOR MANUFACTURERS:				3		3
ARCHITECT ENGINEERS:	1	1				2
ATOMIC INDUSTRIAL FORUM:				1		1

CONCLUSIONS OF UTILITY GROUP ON ATWS

- THE STAFF AND HENDRIE RULES FAIL THE COST-BENEFIT TEST

- ONLY THE UTILITY RULE IS CONSISTENT WITH CURRENT NRC POLICIES

- THE RECORD AND NOTICE FOR THE STAFF AND HENDRIE RULES ARE INADEQUATE

STEPS TO PREPARE FINAL RULE

- o PREPARE TECHNICAL ANALYSIS REPORT OF UTILITY GROUP STUDY ON ATWS
- o FORM A STAFF TASK FORCE CONSISTING OF REPRESENTATIVES FROM NRR, RES AND IE
- o DISTRIBUTE TECHNICAL ANALYSIS REPORT TO TASK FORCE, AND FOR INFORMATION TO CRGR AND ACRS SUBCOMMITTEE
- o TASK FORCE MEETS AND REACHES A CONSENSUS CHOICE FROM THREE ALTERNATIVES:

  A. NO RULE ON ATWS. PUT INTO SEVERE ACCIDENT CONSIDERATION

  B. ADOPT UTILITY PETITION. THIS IS VERY CLOSE TO "ALTERNATIVE" 2A OF NUREG-0460 (EXCEPT FOR WESTINGHOUSE PLANTS)

  C. CONSOLIDATE STAFF RULE AND HENDRIE RULE INTO A REQUIREMENT SIMILAR TO "ALTERNATIVE" 3A OF NUREG-0460. DELETE RELIABILITY ASSURANCE PROGRAM FOR NOW AND ELIMINATE EVALUATION MODELS

- o PRESENT CONSENSUS POSITION TO CRGR
- o PAPER TO COMMISSION

TASK FORCE

R. BAER (IE)

G. BURDICK (RES)

C. GRAVES (NRR)

W. MINNERS (NRR)

A. THADANI (NRR)

C. ROSSI (NRR)

TASK FORCE STEERING

R. BERNERO (RES)

S. HANAUER (NRR)

T. MARTIN (R I)

R. MATTSON (NRR)

J. OLSHINSKI (R II)

J. SNIEZEK (IE)

PROPOSED SCHEDULE

o	PREPARE TECHNICAL ANALYSIS REPORT AND DISTRIBUTE TO TASK FORCE, CRGR AND ACRS SUBCOMMITTEE	9/1/82
o	TASK FORCE MEETS AND REACHES A CONSENSUS	10/21/82
o	START REVIEW BY CRGR	11/3/82
o	REVIEW COMPLETE BY CRGR	12/15/82
o	PRESENT PAPER TO COMMISSION	1/83
o	PUBLISH FOR COMMENT IN FEDERAL REGISTER (60 DAY COMMENT PERIOD)	3/83
o	RECEIVE PUBLIC COMMENTS	5/83

4 ALTERNATIVES

1. NO ATWS RULE (OR INCLUDE ATWS UNDER THE SEVERE ACCIDENT PROGRAM)

2. ADOPT THE PROPOSED OR A MODIFIED VERSION OF THE UTILITY GROUP RULE

3. ADOPT THE STAFF RULE OR A MODIFICATION OF IT

4. ADOPT THOSE PORTIONS OF THE HENDRIE RULE FOR WHICH WE HAVE A TECHNICAL BASIS

SOME ASSUMPTIONS

1. FAILURE TO SCRAM IS 3×10^{-5}/DEMAND

2. FAILURES TO SCRAM ARE 2/3 ELECTRICAL AND 1/3 MECHANICAL

3. ATWS COST IS $10 BILLION

4. FOR BWR'S RECIRCULATING PUMP TRIP IS ALREADY REQUIRED

SOME LIMITS

1. FOR PWR'S THE MODERATOR TEMPERATURE COEFFICIENT WILL BE FAVORABLE 99 PERCENT OF THE TIME FOR WESTINGHOUSE, AND 50 PERCENT OF THE TIME FOR CE AND B&W

2. BWR POOL TEMPERATURE SHOULD NOT GO ABOVE ABOUT 200^{o}F LOCAL TEMPERATURE

3. HUMAN ERROR RATE VS. TIME

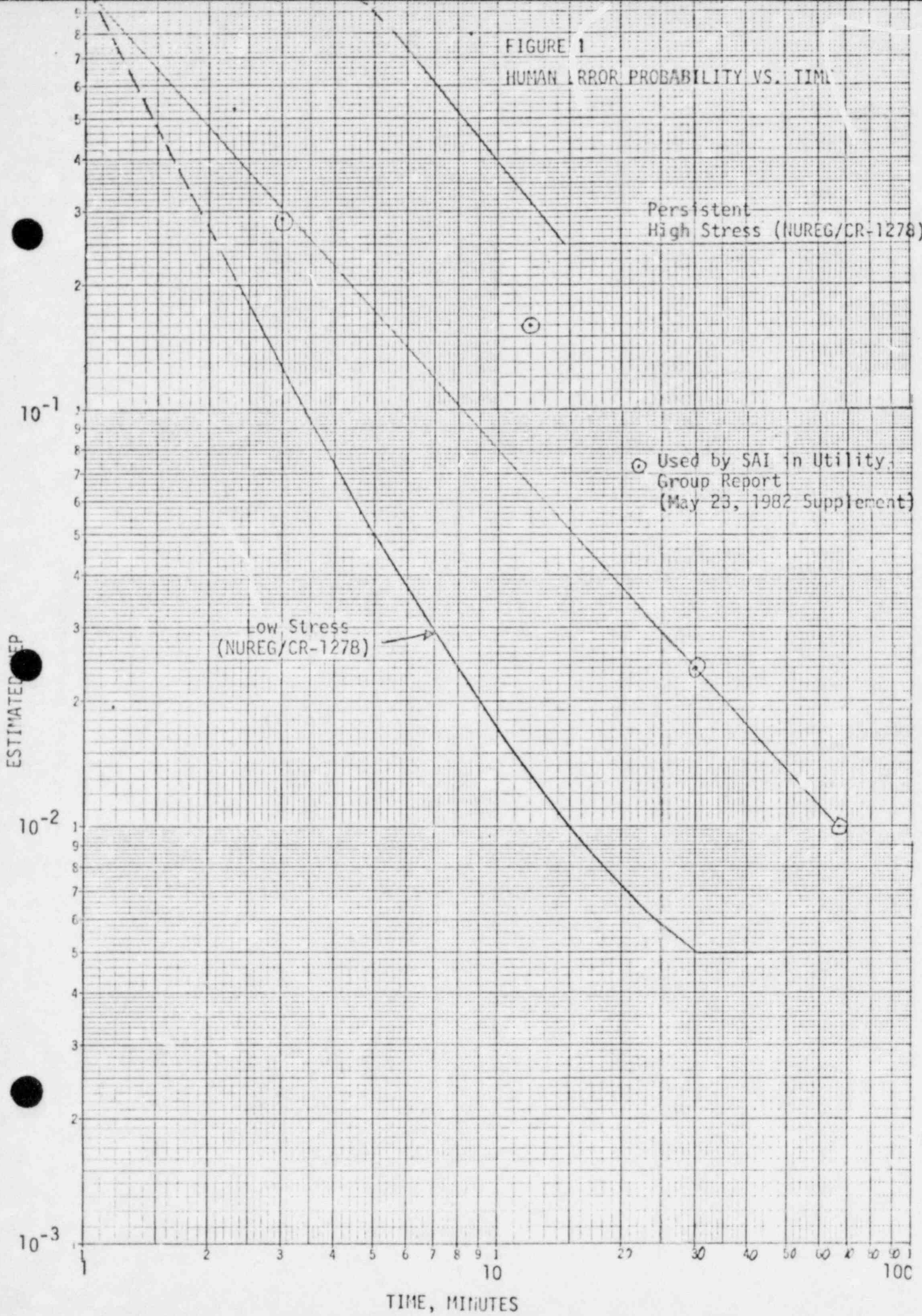


FIGURE 1
HUMAN ERROR PROBABILITY VS. TIME
Persistent High Stress (NUREG/CR-1278)
Used by SAI in Utility Group Report (May 23, 1982 Supplement)
Low Stress (NUREG/CR-1278)
ESTIMATED HEP
TIME, MINUTES
10^{-1}
10^{-2}
10^{-3}
1
10
100

SOME STRATEGY

1. FOCUS ON P_{ATWS} AS FIGURE OF MERIT
2. DO INCREMENTAL VI ANALYSIS
3. USE INDUSTRY COST FIGURES
4. DO SENSITIVITY ANALYSES
5. BE PRESCRIPTIVE, AVOID ANALYSES WHERE POSSIBLE

P_{ATWS}

- PROBABILITY OF AN ATWS SEQUENCE LEADING TO UNACCEPTABLE PLANT CONDITIONS

- $P_{ATWS} \times X = P_{CMA}$

  X = FRACTION OF SEQUENCES LEADING TO LARGE SCALE CORE MELT DUE TO ATWS

- $P_{CMA} \times Y = P_{EFA}$

  Y = FRACTION OF SEQUENCES LEADING FROM LARGE SCALE CORE MELT TO EARLY FATALITY OF AN INDIVIDUAL DUE TO ATWS

  Y INCLUDES CONTAINMENT FAILURE AND DISPERSION

P_{ATWS} VS. SAFETY GOAL

CORE MELT

$$P_{CM} = 1x10^{-4}/YR$$

$$P_{CMA} = \frac{1}{10} P_{CM}$$

$$\boxed{P_{ATWS} = 1x10^{-5}/YR}$$

EARLY FATALITY

$$P_{EF} = 5x10^{-7}/YR$$

$$P_{EFA} = \frac{1}{10} P_{EF}$$

$$P_{ATWS} \times X \times Y = 5x10^{-8}/YR$$

$$P_{ATWS}\ (0.1)(0.1x0.06) = 5x10^{-8}/YR$$

GIVES $P_{ATWS} = 1x10^{-4}/YR$

$$P_{ATWS}\ (1.0)(1.0x0.06) = 5x10^{-8}/YR$$

GIVES $P_{ATWS} = 1x10^{-6}/YR$

$$\boxed{P_{ATWS} = 1x10^{-5}/YR}$$

TABLE 1

BWR ALTERNATIVES

Alternative	Description	P_{ATWS}/yr	Impact (Millions)	V/I	
0. Current Commitment	Recirculation Pump Installed; Scram Discharge Modifications Emergency Procedure Guidelines (EPG)*	$1.3x10^{-4}$	--	--	
1. Utility Proposal Existing Plants	ARI (Diverse Scram) EPG	$4.1x10^{-5}$	$3.3M(A)	8.1	Utilities Will Do
2. Utility Proposal New Plants	ARI EPG 86 gpm or higher flow manual operation (also increase concentration at 43 gpm)	$2.3x10^{-5}$	$2.1M(B) ($0.2M-$1.2M to double concentration based on very preliminary utility estimates)	2.6, based on $2.1M 27, based on $0.2M	
3. Automatic SLCS	a. 43 gpm and EPG	$1.5x10^{-5}$	$14.3M(C)	0.55, based on 1	
	b. 86 (or greater)** gpm or enriched boron	$4.8x10^{-6}$	$23.6M(D)	0.46, based on 1	

*Large uncertainty in EPG calculations. At 43 gpm flow of SLCS, the EPGs were assumed not to reduce P_{ATWS}.
**A higher flow than 86 gpm may be required. The analysis would be plant-specific.

See next page for footnotes A-D.

Basis for Cost Estimates

(A) \$3.3 million for ARI includes hardware, engineering and installation of \$860,000. A down time of 2 days for installation and 2 days for inadvertent trip (\$500,000/day), operation and maintenance (\$25,000 for 30 years) and AFUDC (\$600,000) bring the total to \$3.3 million.

(B) No cost estimates were provided for manual 86 gpm backfit by Utilities in their report. It was assumed that if the flow could be injected through the HPCI line for BWR-4 plants, the required down time would be small (assume 2 days). Presumably, no more spurious actuations than the current system would occur. This represents an upper limit cost as Utilities feel that they can achieve 86 gpm equivalence at less cost for BWR-4 plants by adding heaters and doubling the concentration.

Hardware, engineering and installation	\$1.0M
Down time	\$1.0M
AFUDC (estimate)	\$0.1M
Total	\$2.1 Million

Many BWR-5 and -6 plants have made provisions for increasesd SLCS flow.

(C) No cost estimate provided for 43 gpm automatic initiation by Utilities. However, the installation costs would be lower than for 86 gpm systems. Based on the 86 gpm (Alternative 3A) and "Alternative 4A" estimates, we assume:

Hardware, engineering, installation, AFUDC	\$2.0M
Replacement power	\$5.0M
Analysis (once only)	\$1.0M
Operation and maintenance	\$3.75M
Inadvertent trip	\$2.5M
Total	\$14.3 Million

(D) For 86 gpm automatic initiation, costs are (as provided by Utility Group):

Automatic boron injection	\$3.35M
AFUDC	\$0.46M
Replacement power (20 day outage)	\$10.00M
Analysis (NRC; once only)	\$1.00M
Operation and maintenance	\$3.75M
Inadvertent trip (10 day outage)	\$5.00M
Total	\$23.6M

TABLE 2

WESTINGHOUSE ALTERNATIVES

Alternative	Description	P_{ATWS}/yr	Impact (Millions)	V/I	
0	Base Case	2.8×10^{-5}	--	--	
1	Diverse Auxiliary Feedwater and Turbine Trip	3.0×10^{-6}	\$2.8M(A)	2.7	Utilities Will Do
2	Diverse AFW and T/T Diverse Scram System	$\sim 1.0 \times 10^{-6}$	\$3.0M(B) (\$5.8M Total)	0.2	

(A) Hardware, engineering, installation — \$1.0M
AFUDC — \$0.06M
Operation and maintenance — \$0.75M
Inadvertent trip — \$1.0M
Total — \$2.8M

(B) Based on CE, B&W estimates. None provided for Westinghouse.

TABLE 3

CE/B&W ALTERNATIVES

Alternative	Description	P_{ATWS}/yr	Impact (Millions)	V/I
0	Base Case	7.5×10^{-5}	--	--
1	- Diverse Scram System - Diverse Auxiliary Feedwater and Turbine Trip	2.1×10^{-5}	\$5.5M(A)	2.9 Utilities Will Do
2	- Diverse Scram System - Diverse AFW and T/T - Improve MTC by Adding Safety Valves or Burnable Poisons	4.0×10^{-6}	\$10.0M(B) (\$15.5M Total)	0.5

(A) Use B&W values (CE close)

Hardware, engineering, installation, AFUDC	\$2.0M
Inadvertent trip	\$3.0M
Operation and maintenance	\$0.5M
Total	\$5.5M

(B) Use B&W values (CE close)

Hardware, engineering, installation	\$1.6M
Replacement power	\$5.0M
Analysis (once only)	\$1.0M
Operation and maintenance	\$0.4M
Inadvertent trip	\$2.0M
Total	\$10.0M

Conradi (2)

Review and Evaluation of

the Comments of the

Utility Group on ATWS

October 22, 1982

EI ROLE

- Review of utility submittal
- Determine validity of PRA technical approach
- Determine validity of cost-benefit studies
- Determine validity of conclusions based on presented information

Information Reviewed

- Utility submittal (April 23, 1982)
  - Main Report
  - SAI Analysis
  - Update of May 12, 1982
- Utility presentation response to questions

EI EVALUATION PROCESS

REVIEW UTILITY COMMENTS →	ASSESS ANALYSIS APPROACH →	IDENTIFY KEY ISSUES BY REACTOR TYPE →	DETERMINE IMPACT OF KEY ISSUES
• PRA Models • Cost Benefit • No Engineering Analyses	• Event Trees • Initiating Events • Event Probabilities • Common Cause • Human Error	• Contribution to Risk • Baseline Case • Utility Rule • Staff and Hendrie Rule	• Sensitivity Studies

SUMMARY EVALUATION

- Comprehensive PRA treatment, consistent with latest guidelines
- Results are sensitive to underlying definitions and assumptions
- Uncertainties associated with cost estimates
- Good application of PRA

UTILITY PRA PROCESS

- Separate analysis for each reactor type - generic
- Detailed event trees
- Initiating events from EPRI NP-801
- Event probabilities - existing data base
- Human errors considered
- Determined frequency of unacceptable plant conditions
- Comparison with NRC estimates of Staff Rule

EVALUATION OF THE VALIDITY OF UTILITY PRA APPROACH

Event Tree Structure	- Adequately represents ATWS mitigation requirements
Success Criteria	- Subjective selection in key areas
Initiator Selection	- Consistent with current PRAs
Initiator Frequency Determination	- Used best available data
Event Probabilities	- Estimates from other published analyses ~~of~~ or engineering judgment
Human Factors	- Appropriate method for Inclusion in PRA
Competing Risks	- Not addressed

UTILITY COST-BENEFIT APPROACH

- DERIVED VALUE-IMPACT RATIO FOR EACH RULE FOR EACH REACTOR
- VALUE CALCULATED AS COST SAVINGS DUE TO AVERTED UNMITIGATED ATWS EVENTS
- VALUE = Δ FREQUENCY x 30 YEARS x $10 BILLION
- IMPACT CALCULATED AS COST TO IMPLEMENT RULE
- IMPACT ADDRESSED EQUIPMENT COST, ENGINEERING, INSTALLATION, ANALYSIS, REPLACEMENT POWER, EQUIPMENT OPERATING COSTS OVER THE LIFE OF THE PLANT
- UTILITY PERSONNEL DERIVED COSTS BASED ON ESTIMATES AND SOME EXPERIENCE

SUMMARY EVALUATION OF UTILITY COST ANALYSIS

- Analysis and replacement power dominate cost estimates
- Cost of unmitigated ATWS uncertain
- Cost of mitigated ATWS not included
- Value - impact ratio sensitive to assumptions and definitions

SUMMARY OF UTILITY ANALYSIS

Plant Type	Frequency of Unacceptable Plant Consequences/yr: Baseline	Frequency of Unacceptable Plant Consequences/yr: Utility Rule	Value/Impact: Utility Rule	Value/Impact: Staff Rule	Value/Impact: Hendrie Rule
GE	1.3×10^{-4}	1.5×10^{-5}	2.9	.10	.08
W	5.6×10^{-6}	2.6×10^{-6}	.3	.06	.04
CE	2.7×10^{-5}	5.7×10^{-6}	1.2	.09	0.0
B&W	2.3×10^{-5}	5.6×10^{-6}	.9	.09	0.0

SUMMARY OF BWRs

Configuration		Frequency	Cost ($M)	Value/Impact Ratio
Baseline		1.3×10^{-4}	---	---
Utility Rule		1.5×10^{-5}	11.9	2.9
Staff Rule	pre-84	6.5×10^{-6}*	27.5**	.09***
	post-84	6.5×10^{-7}*	42.6**	.10***
Hendrie Rule		6.5×10^{-6}*	30.5**	.08***

FACTORS IN RISK REDUCTION

- ARI REDUCES THE FAILURE TO SCRAM PROBABILITY FROM 3×10^{-5} TO 1×10^{-5}
- RPT WHICH ALLOWS ARI TO BE EFFECTIVE
- ASSUMPTION OF AN ALLOWABLE SUPPRESSION POOL TEMPERATURE AT 285°F
- EMERGENCY OPERATING PROCEDURES TO REDUCE REACTOR WATER LEVEL

BWR COST SUMMARY

	Cost of Utility Rule	Additional Cost for Staff Rule		Additional Cost for Hendrie Rule
		3A	4A	
Analysis	0	5	6	---
Equipment Design and Installation	4.75	3.8	7.9	---
Replacement Power*	6.0	15	25	---
Other	.75	3.75	3.75	---
Total	11.5	27.5	42.6	30.5

*Includes replacement power costs for inadvertent trips caused by modifications.

WESTINGHOUSE SUMMARY

Configuration	Frequency	Cost ($M)	Value/Impact Ratio
Baseline	5.6×10^{-6}	---	---
Utility Rule	2.6×10^{-6}	2.8	.30
Staff Rule	1.0×10^{-6}	7.8*	.06**
Hendrie Rule	1.0×10^{-6}	10.8*	.04**

FACTORS IN RISK REDUCTION

- AUTOMATIC INITIATION OF AUXILIARY FEEDWATER
- PROVISION OF REDUNDANT TURBINE TRIP ACTUATION CIRCUITRY

WESTINGHOUSE COST SUMMARY

	Cost of Utility Rule	Additional Cost for Staff Rule	Additional Cost for Hendrie Rule
Analysis	0	5	---
Equipment Design and Installation	1.05	1.45	---
Replacement Power	1.0	1.0	---
Other	.75	.37	---
Total	2.8	7.8	10.8

COMBUSTION ENGINEERING SUMMARY

Configuration		Frequency	Cost ($M)	Value/Impact Ratio
Baseline		2.7×10^{-5}	---	---
Utility Rule		5.7×10^{-6}	5.4	1.2
Staff Rule	pre-84	N.C.	7.4*	N.C.
	post-84	1×10^{-6}	15.2*	.09**
Hendrie Rule		1×10^{-6}	10.5*	N.C.

Factors in Risk Reduction

- Provisions of supplementary scram system
- Automatic initiation of auxiliary feedwater

CE COST SUMMARY

	Cost for Rule Implementation ($M)		
	Cost of Utility Rule	Additional Cost for Staff Rule	Additional Cost for Hendrie Rule
Analysis	0	5.0	---
Equipment Design and Installation	1.66	2.5	---
Replacement Power	3.0	7.0	---
Other	.75	.67	---
Total	5.41	15.2	10.5

BABCOCK AND WILCOX SUMMARY

Configuration		Frequency	Cost ($M)	Value/Impact Ratio
Baseline		2.3×10^{-5}	---	---
Utility Rule		5.6×10^{-6}	5.9	.9
Staff Rule	pre-84	N.C.	6.8*	N.C.
	post-84	1×10^{-6}	15.8*	.09**
Hendrie Rule		1×10^{-6}	9.8*	N.C.

FACTORS IN RISK REDUCTION

- PROVISION OF SUPPLEMENTARY SCRAM SYSTEM
- AUTOMATIC INITIATION OF AUXILIARY FEEDWATER

B&W COST SUMMARY

Cost for Rule Implementation ($M)

	Cost of Utility Rule	Additional Cost for Staff Rule	Additional Cost for Hendrie Rule
Analysis	0	5.0	---
Equipment Design and Installation	2.17	3.1	---
Replacement Power	3.0	7.0	---
Other	.75	.67	---
Total	5.9	15.8	9.70

UTILITY RULE AS ANALYZED

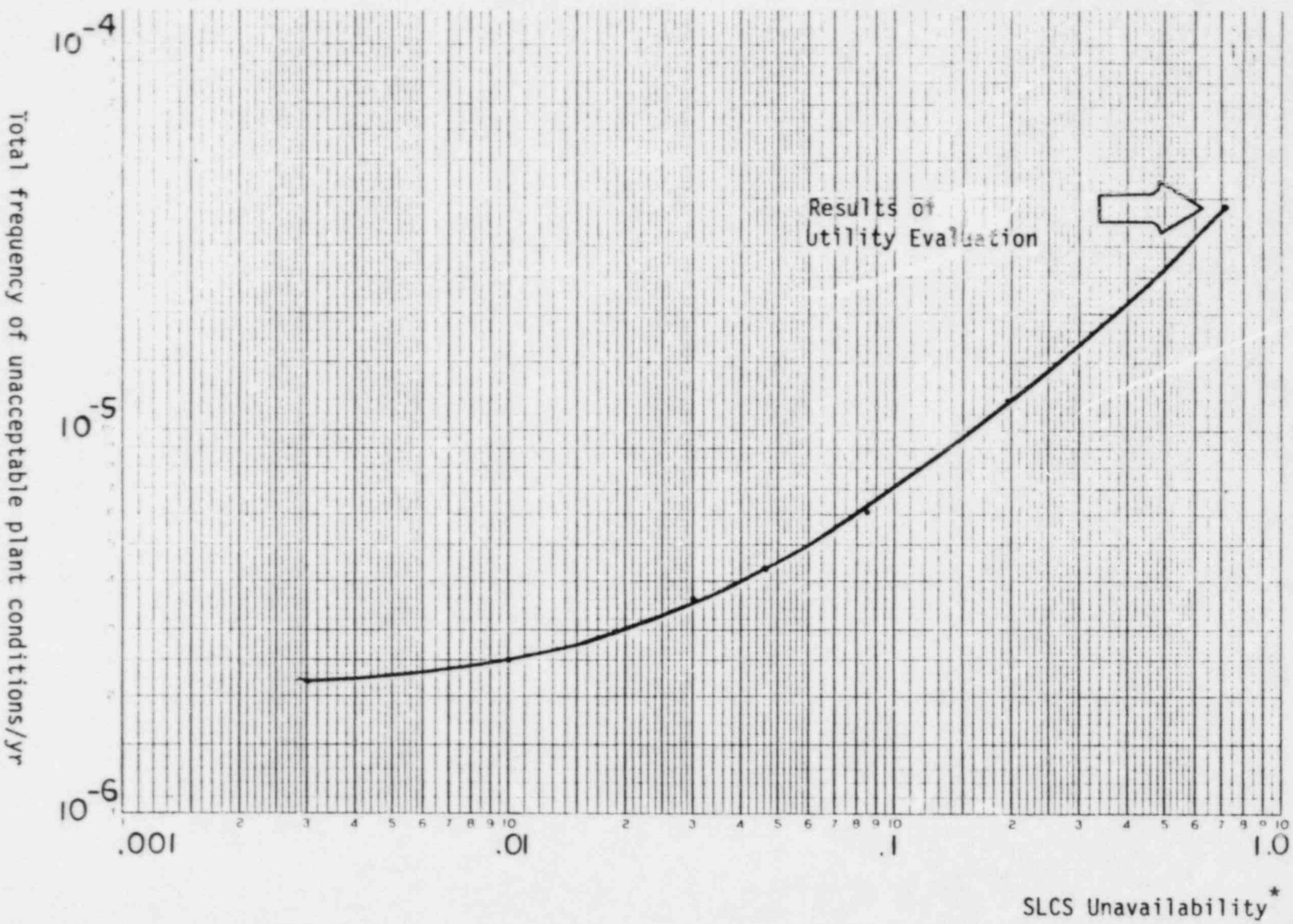
- GE - ARI, RPT, SDV, PROCEDURES, (285°F S.P. TEMP.)
- W - AMSAC FOR TT, AFW
- CE - SPS, AMSAC FOR AFW
- B&W - BUSS, AMSAC FOR AFW

KEY ISSUES

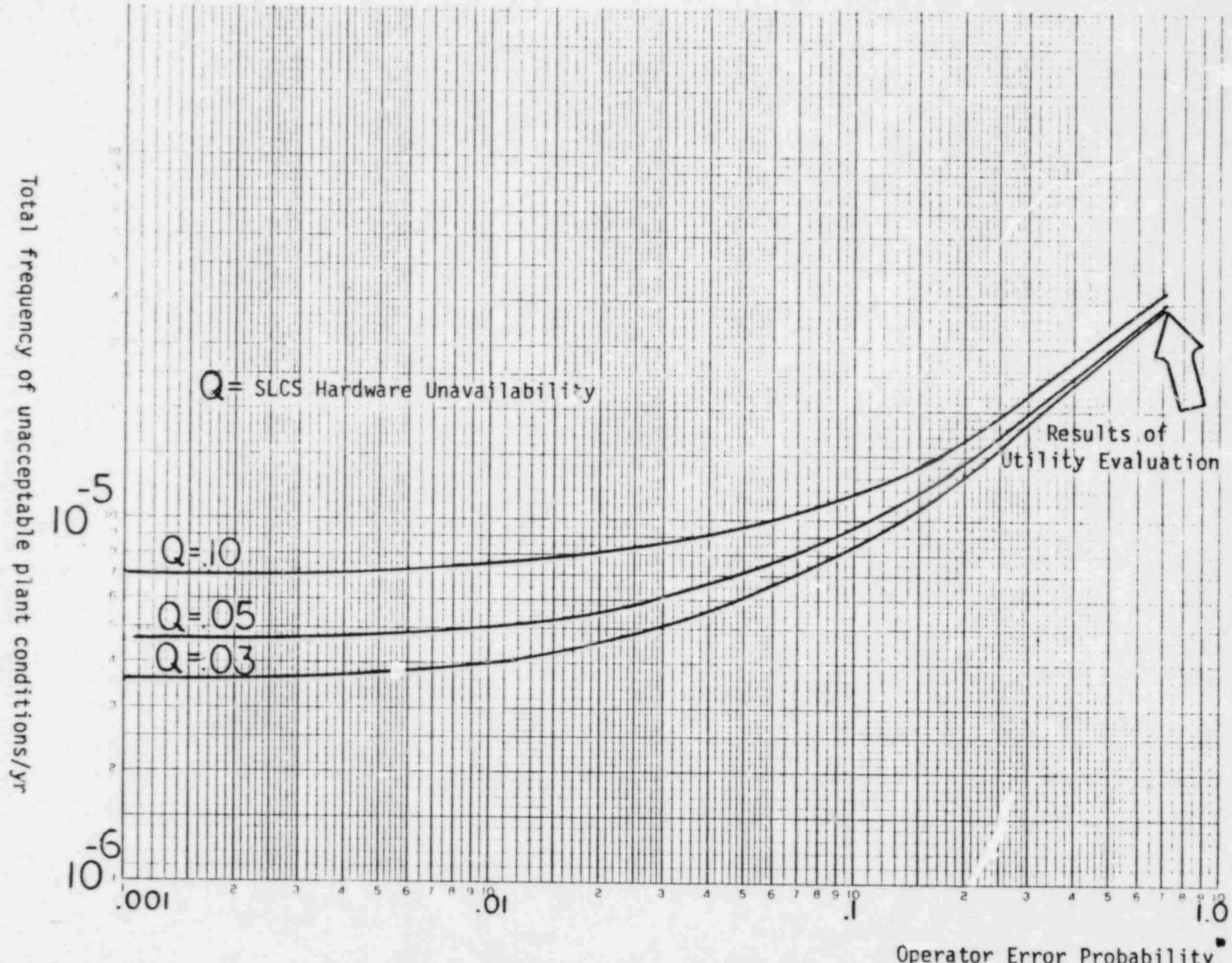
- SLCS Failure Probability
- Suppression Pool Temperature Limits for BWRs
- Ratio of Electrical vs. Mechanical Failures in the RPS
- RCS Integrity in PWRs
- Initiation of High Pressure Injection in PWRs
- Auxiliary Feedwater Reliability
- Comparison of Utility Analyses and NRC Analyses
- Generic vs. Specific Analyses
- Cost Uncertainties

SLCS FAILURE PROBABILITY

- Dominated by operator error
- Error probability based on time available for SLCS initiation
- 285°F Evaluation require other operator actions
- Error probability derived from NUREG/CR-1278 high stress/low stress curve
- Sensitivity study



*Weighted average with respect to initiating event frequencies. High power and low power events included.



*Weighted average with respect to initiating event frequencies.
High power and low power events included.

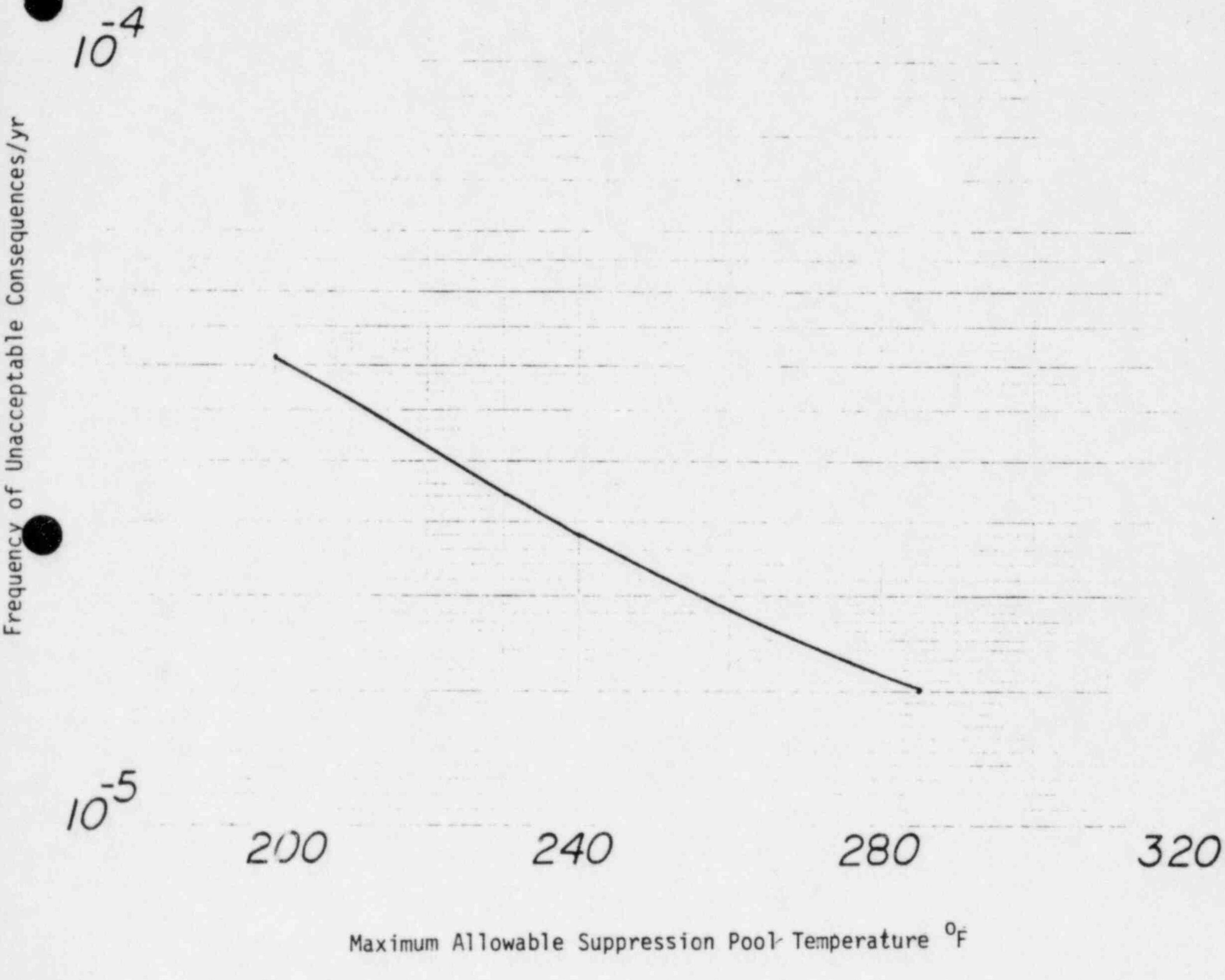
BWR SUPPRESSION POOL TEMPERATURE

- Baseline configuration allows very little time for operator action before suppression pool temperature equals 200°F

- 285°F suppression pool temperature does not overpressure containment. Subcooling maintained

- Allows 12 minutes for operator action

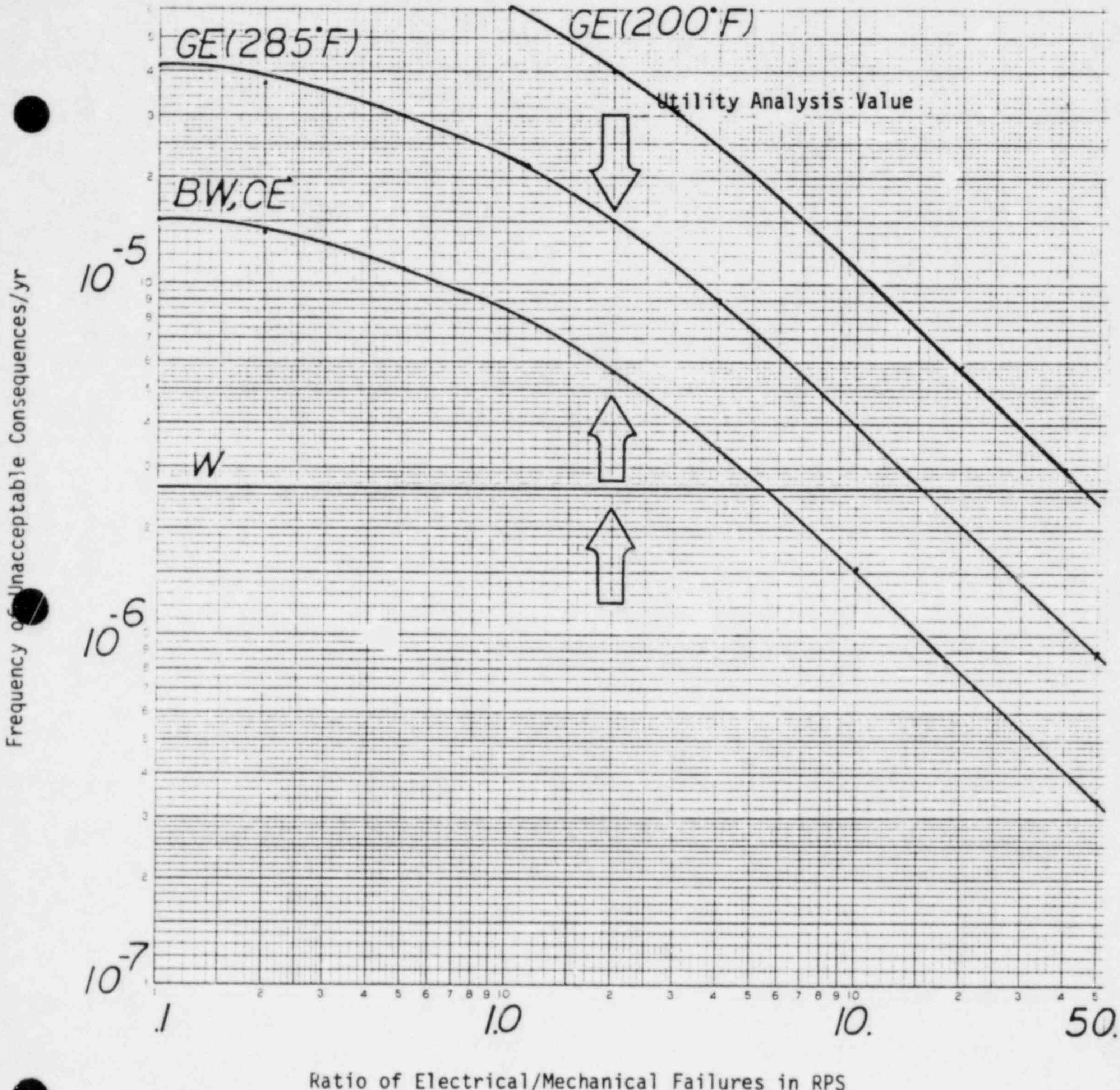
- Sensitivity study



Variation in Utility Results to
Acceptable Suppression Pool Temperature

RATIO OF ELECTRICAL TO MECHANICAL FAILURES IN THE RPS

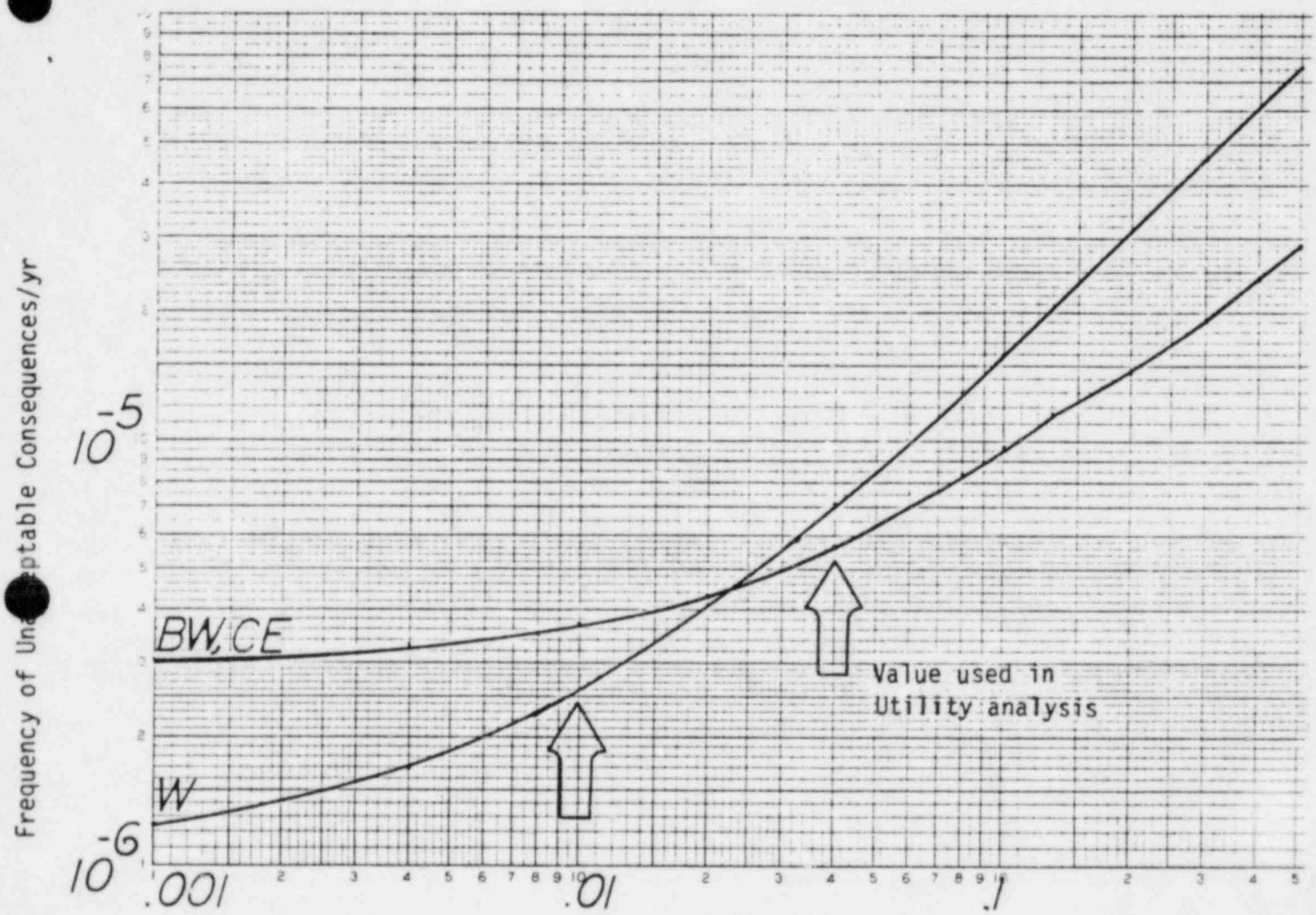
- Direct impact on risk
- ARI, SPS, BUSS effective against electrical failures only
- Limited data to rely on
- Utility position is 2 to 1
- No discussion of differences between BWR and PWR
- Sensitivity study



Variation of Utility Rule Results as a
Function of Electrical/Mechanical Failures.

RCS INTEGRITY

- Severity of initial pressure spike dependent on value of MTC, and other parameters
- Success defined as not exceeding specified service levels
- Treated probabilistically by probability to exceed favorable MTC
- Sensitivity study



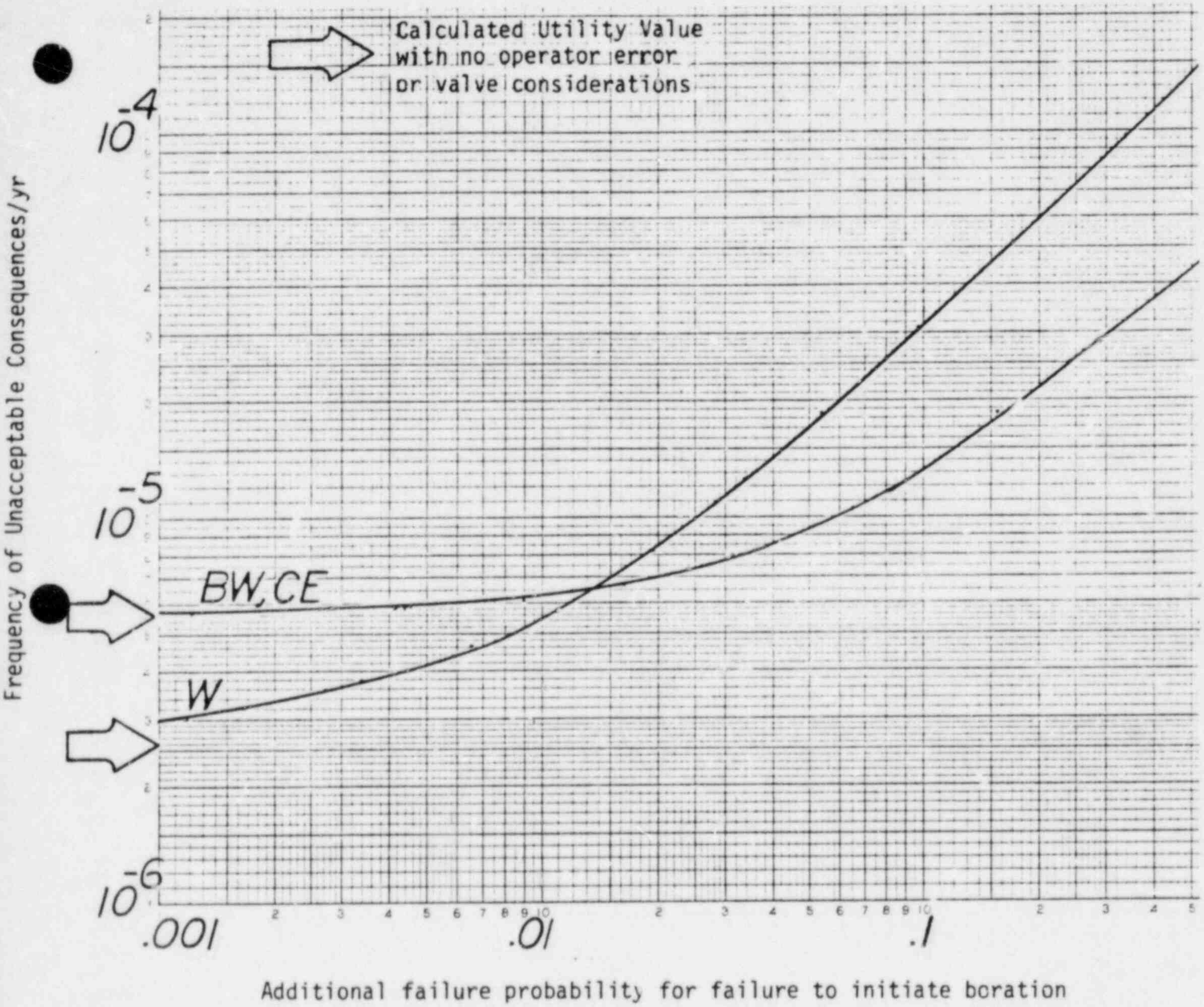
Probability of Unfavorable Moderator Temperature Coefficient
(Probability of event Z for high power,later years)

Variation * of Utility Results to Selection
of Probability of Unfavorable MTC.

* This calculation assumes, that for B&W/CE plants the relationship between the first year MTC and later years MTC will remain constant as the MTC is varied

INITIATION OF HIGH PRESSURE INJECTION

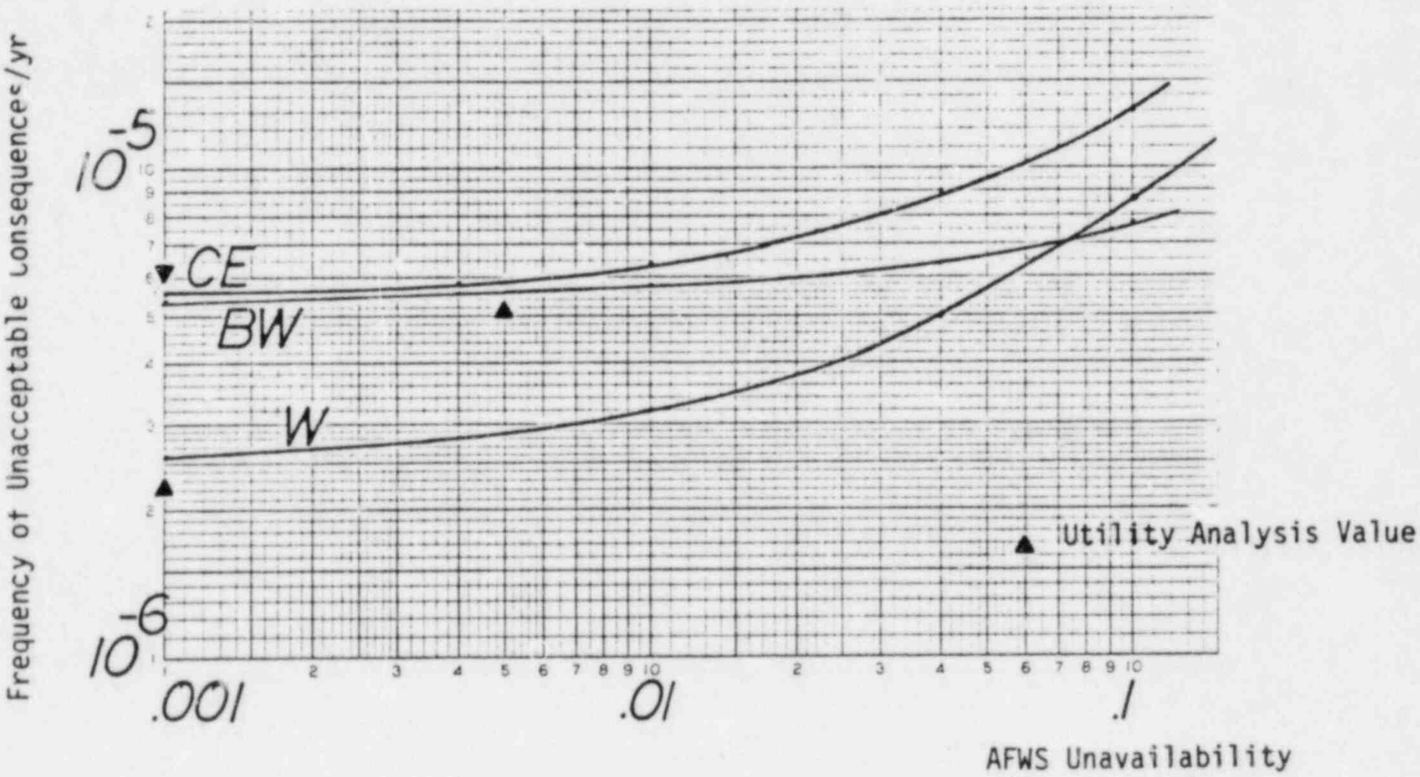
- Emergency boration required for all ATWS
- Automatic initiation implies SI trip signal reached
- Manual initiation implies inclusion of operator error may be appropriate
- Consideration of valve operability
- Sensitivity study



Variation of Utility Rule Results as a
Function of Additional Failure
Probability for Emergency Boration
Due to Either Operator Error or
Valve Operability Considerations.

AUXILIARY FEEDWATER RELIABILITY

- Direct impact on risk
- Provision of auto-start circuitry
- Stringent success criteria for ATWS response
- Few previous studies to rely on (not ATWS specific)
- Reduction based on engineering judgment
- Sensitivity Study



Variation of Utility Rule
Results as a Function of
AFWS Unavailability.

GENERIC VERSUS SPECIFIC ANALYSIS

- OPERATION WITH BLOCKED PORV

- BWR CONTAINMENT DESIGN

COMPARISION OF UTILITY AND NRC ANALYSIS

- UTILITY ANALYSIS EMPLOYS DETAILED EVENT TREES
- NRC ANALYSIS NOT WELL DOCUMENTED
- NOT CLEAR UTILITY MODEL WILL SHOW STAFF RULE TO BE 10^{-6}

COST UNCERTAINTIES

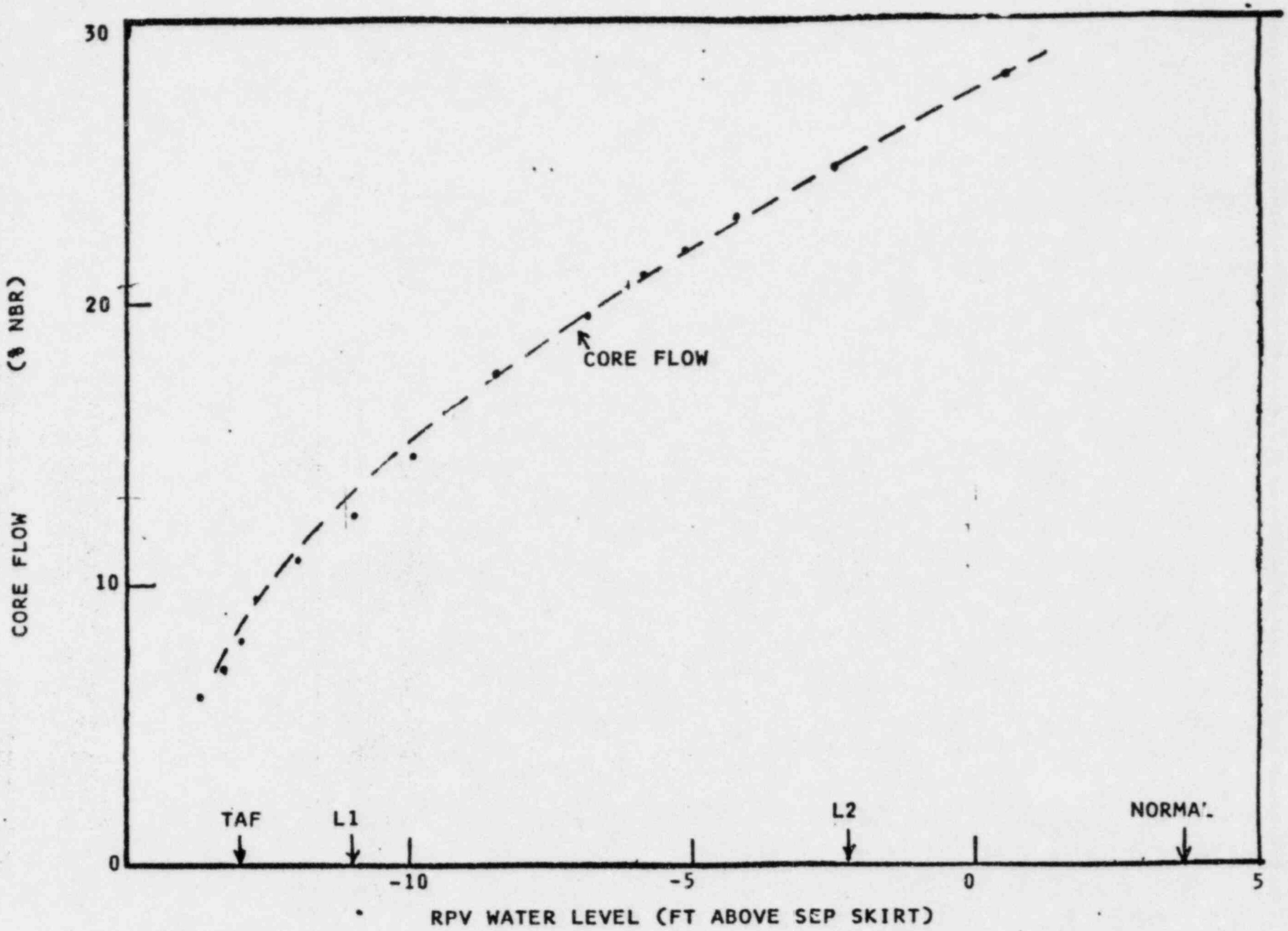
- COST OF AN ATWS ($10B)
- COST FOR RULE IMPLEMENTATION MAY BE PLANT SPECIFIC
- ANALYSIS AND REPLACEMENT POWER DOMINATE COST ESTIMATES

BWR SENSITIVITY TO HUMAN ERROR

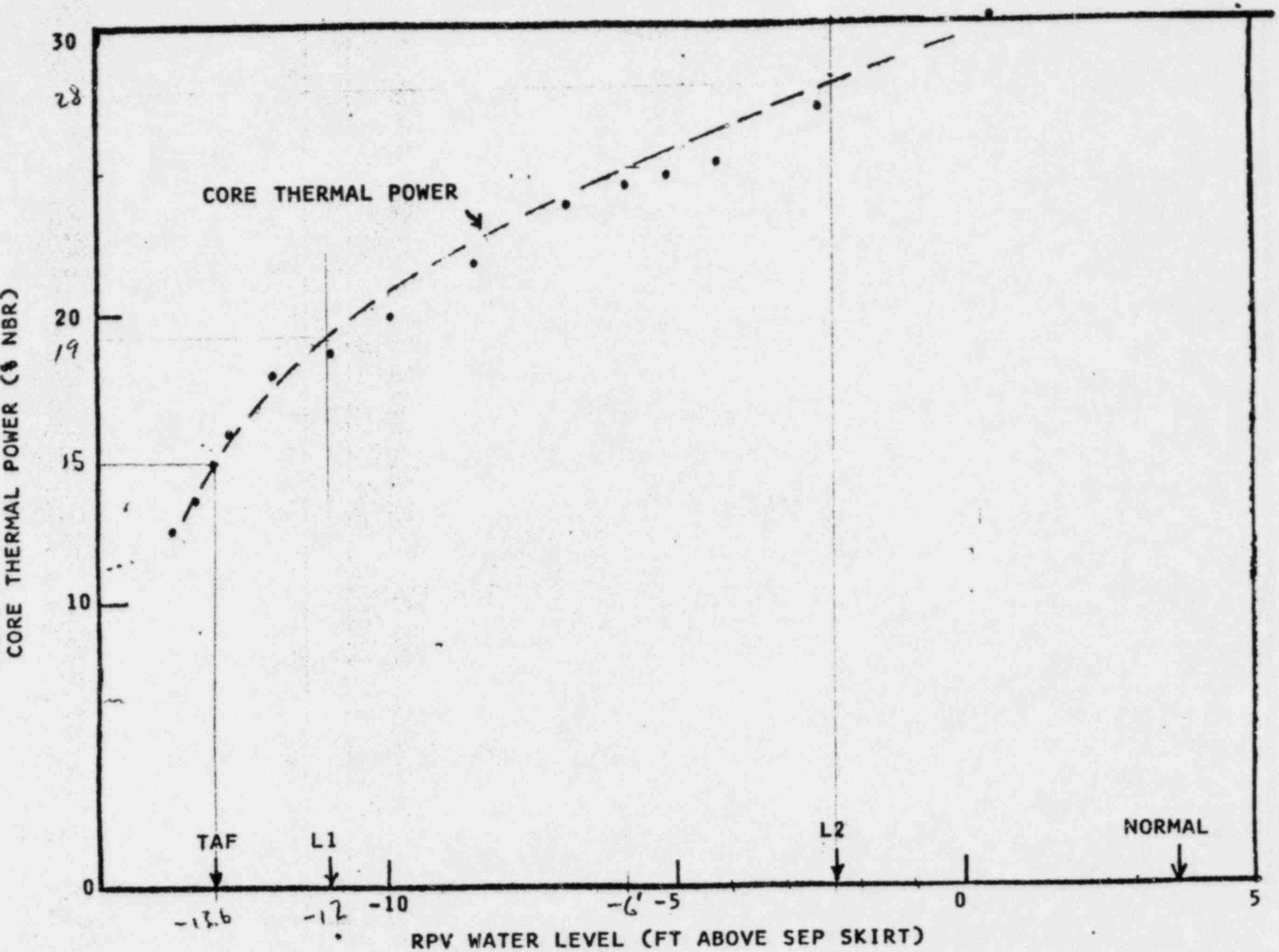
IN

INITIATION OF PROCEDURE

	PROBABILITY OF UNACCEPTABLE CONSEQUENCES
NRC BASE CASE (PRE-UTILITY PROPOSAL)	2 E-4
RECALCULATED BASE LINE	1.3 E-4
ORIGINAL RULE (NO CREDIT FOR OPERATOR ACTION)	4.1 E-5
AMENDED RULE EQUIVALENT TO 10 MINUTE OPERATOR DELAY	1.6 E-5



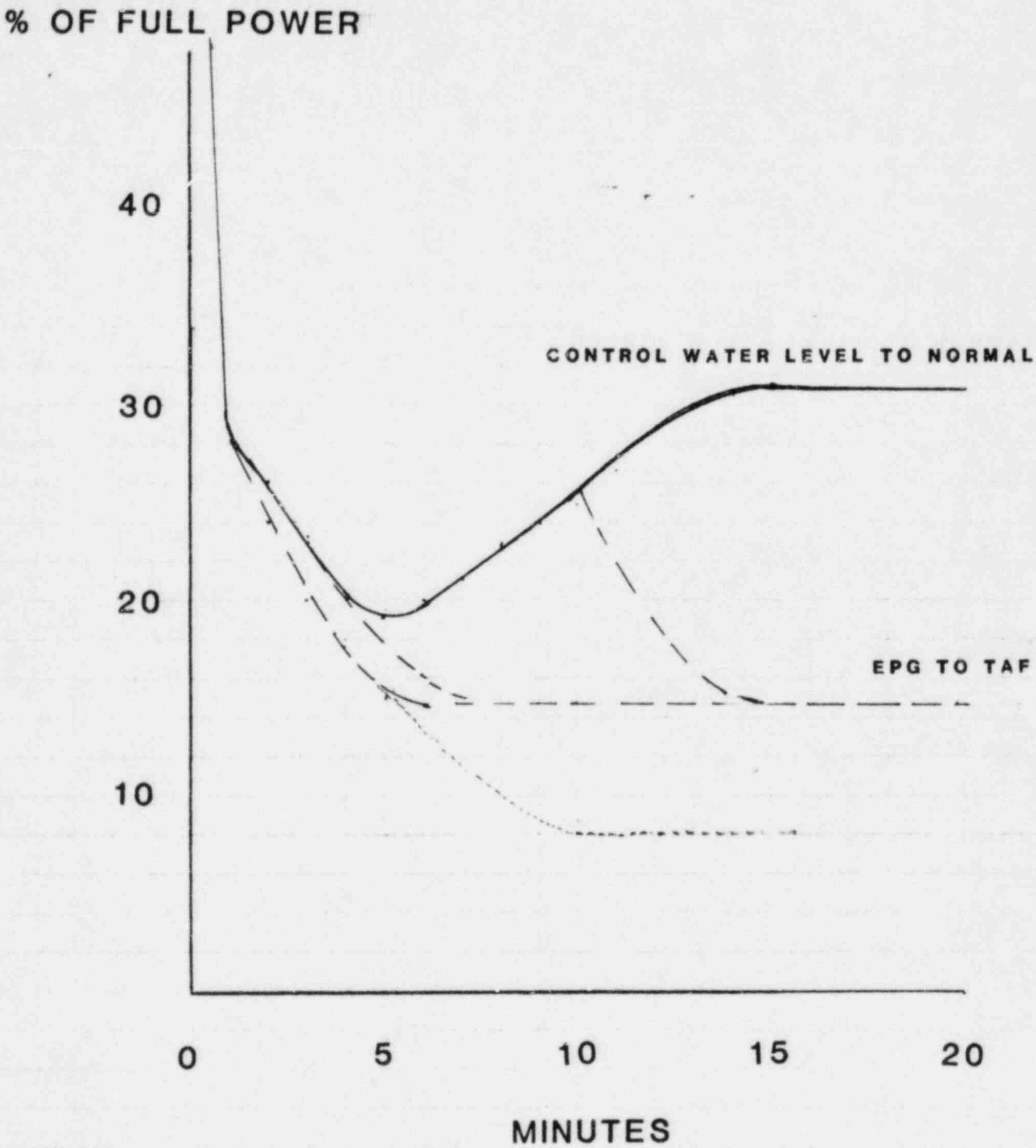
REACTOR CORE FLOW VS RPV WATER LEVEL - REDY ESTIMATE



REACTOR CORE THERMAL POWER VS RPV WATER LEVEL - REDY ESTIMATE

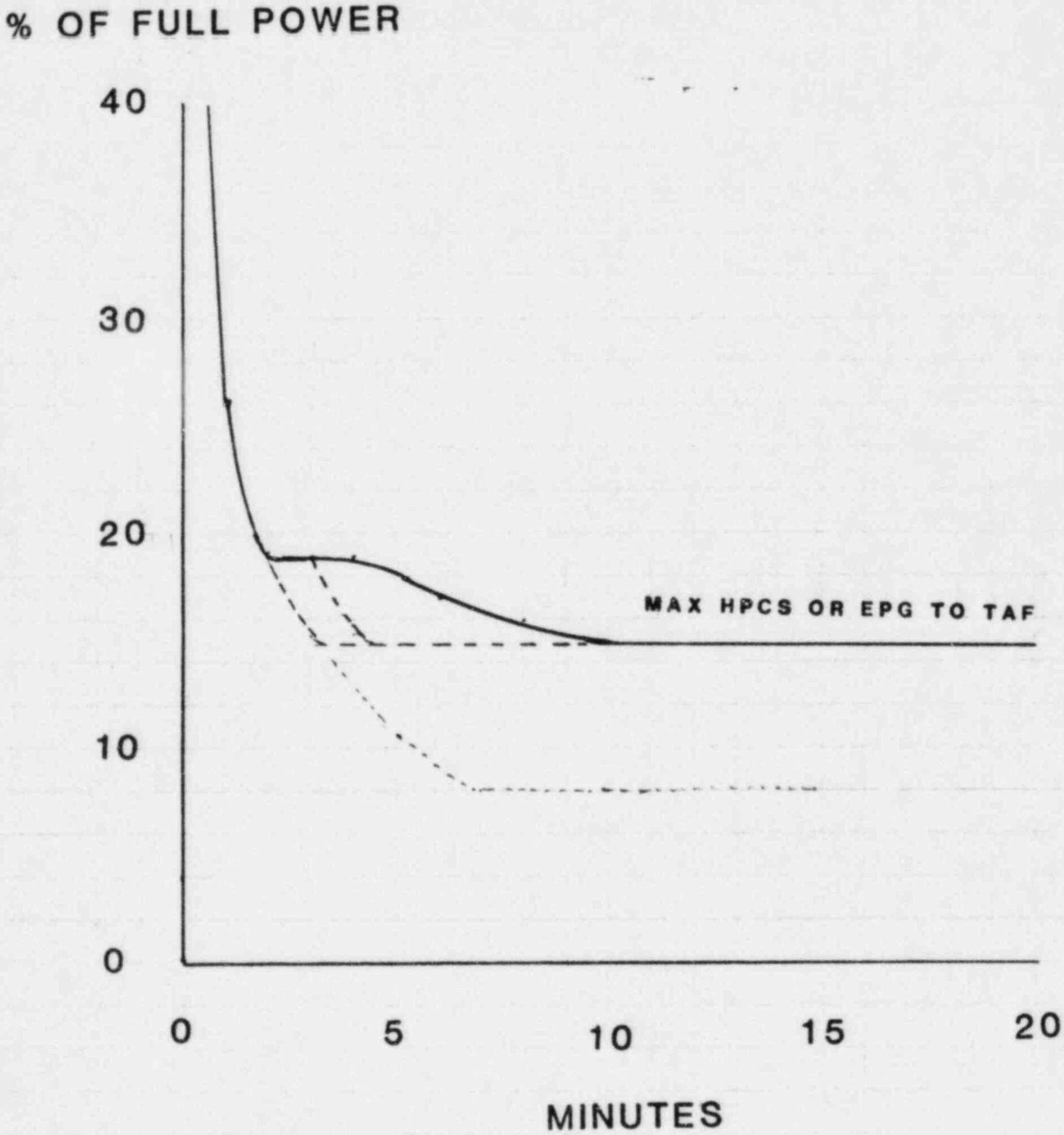
REACTOR POWER ESTIMATE

BWR-4 NO BORON HPCI & RCIC



REACTOR POWER ESTIMATE

BWR-5 OR 6 NOBORON HPCS & RCIC



TURBINE TRIP ATWS

(70% OF TRANSIENTS)

TIME/POOL TEMP.	CONDITION	ACTION
0/90	100% POWER TURBINE TRIP POWER, PRESSURE INCREASE, RPT, POWER DECREASE TO 25-40% TURBINE BYPASS OPEN TO 25% SRV'S OPEN 0-15% POWER TO POOL.	MODE SW TO S/D
1/104	(ASSUME ARI UNSUCCESSFUL)	ATTEMPT SCRAM MONITOR POOL.
2/108	POOL TEMP. INCREASE 3.75°/MIN W/O POOL COOLING	
3/112		START SLCS THROTTLE FW ALIGN RHR TO POOL
4/115	RPV LEVEL DROPPING TO L2 POWER DECREASING	TERMINATE HPCI/RCIC
5/119	RPV LEVEL ABOUT -72" POWER $\leq$ 25% (ALL TO CONDENSER) BORON MIXING IN CORE.	MONITOR CONDITIONS
10/119	POWER SLOWLY DECREASING (ASSUME POOL COOLING BEGINS HERE TEMP. DROPS .5°/MIN.)	
28/110	HOT SHUTDOWN ACHIEVED	CONTINUE BORON INJECTION.

IF OPERATOR ACTION WERE DELAYED 10 MINUTES, THE MAXIMUM POOL TEMPERATURE WOULD BE 149°

BWR ATWS PRA

ORIGINAL RESULT 4.1×10^{-5}

- DOMINATED BY TURBINE TRIP (70%)
- HEP = .99

WITH EPG 1.6×10^{-5}

- OPERATOR CAN DELAY 10 MINUTES ON TURBINE TRIP EVENT AND STILL BE SUCCESSFUL.
- HEP $\leq$ .16

MSIV CLOSURE ATWS

TIME/POOL TEMP.	CONDITION	ACTION
0/90	100% POWER. MSIV'S TRIP POWER, PRESSURE INCREASE RPT POWER DECREASE TO 25-40 FW TO ZERO (STEAM DRIVEN) RPV LEVEL AND POWER DROP.	MODE SW TO S/D
1/106	RPV LEVEL AT L2, POWER 28% HPCI/RCIC INITIATE (ARI FAILS)	ATTEMPT SCRAM MONITOR POOL
2/112	RPV LEVELS DROP AS SRV FLOW EXCEEDS HPCI/RCIC	INITIATE SLCS STOP HPCI/RCIC STOP FW (ELEC. PUMPS) ALIGN RHR TO POOL.
10/146	RPV LEVEL NEAR TAF POWER 8% TPOOL AT HCTL	CONTROL LEVEL BEGIN RPV DEPRESS W/SRV
27/217	HOT S/D BORON IN CORE	RAISE WATER LEVEL TO MIX BORON
29/221	HOT S/D ACHIEVED	CONTINUE BORON INJECTION.

MSIV CLOSURE EVENT

CONTAINMENT TEMPERATURE SENSITIVITY

SLCS FLOW OF 43 GPM

TAF WATER LEVEL = 8% POWER

	TIME DELAY IN INITIATION		
BWR-4 WITH HPCI, RCIC	0	2	10
MAINTAIN NORMAL LEVEL	220	235	283
EPG	211	221	264
EPG NO BLOWDOWN	168	176	221
BWR-5 OR 6 WITH HPCS, RCIC			
MAINTAIN NORMAL LEVEL	202	207	229
EPG	202	209	243
EPG NO BLOWDOWN	159	166	200

VALUE IMPACT METHODOLOGY

- VERY CONSERVATIVE ASSUMPTION IN VALUE-IMAPCT WAS THAT "UNACCEPTABLE CONDITIONS" LEAD TO WORST CASE ATWS CONSEQUENCES.

- ON VALUE SIDE WE ATTEMPTED TO USE NRC GENERATED ESTIMATES FOR AN ATWS EVENT. BACK CALCULATED VALUES FROM NUREG-0460 WHICH WERE VARIABLE. USED HIGH SIDE ESTIMATE OF 10 BILLION DOLLARS ALTHOUGH WE BELIEVE IT IS HIGH AND INCLUDES IRREVELANT ITEMS.

  VALUE = (COST OF ATWS) x (REDUCTION IN PROBABILITY/YEAR) x (REACTOR LIFETIME)

- BASE CASE CORE MELT ATWS USED RELIABILITY NUMBERS AS QUOTED BY NRC EXCEPT FOR IMPROVEMENTS AS INDICATED IN REPORT

- COST DATA WAS COLLECTED FROM UTILITY GROUP MEMBERS.

IMPACT (COST) OF UTILITY RULE - GE

INITIAL IMPACTS		COST (MILLIONS
HARDWARE COSTS		$0.52
ARI	$ 60,000	
RPT	130,000	
SDV	335,000	
ENGINEERING COSTS		1.70
ARI	200,000	
RPT	100,000	
SDV	1,400,000	
INSTALLATION COSTS		1.87
ARI	600,000	
RPT	450,000	
SDV	825,000	
AFUDC		0.66
RADIATION EXPOSURE		$ 0
REPLACEMENT POWER DURING INSTALLATION		3.0
		$7.75
CONTINUING IMPACT DURING LIFE OF PLANT		
ANALYSIS REQUIREMENTS		0
OPERATION & MAINTENANCE		0.75
INADVERTENT TRIP		3.0
		$ 3.75
TOTAL IMPACT - 30-YEAR LIFE		$11.50

IMPACT (COST) OF STAFF RULE - GE

	ALTERNATIVE 3A (MILLIONS)	ALTERNATIVE 4A (MILLIONS)
INITIAL IMPACTS		
AUTOMATIC BORON INJECTION	$ 3.35	$ 7
AFUDC	0.46	0.9
RADIATION EXPOSURE	0	0
REPLACEMENT POWER	10.0	15.0
	13.8	22.9
CONTINUING IMPACT DURING LIFE OF PLANT		
ANALYSIS REQUIREMENTS	5.0	6.0
OPERATION & MAINTENANCE	3.75	3.75
INADVERTENT TRIP	5.0	10.00
	$13.7	$19.7
TOTAL IMPACT -- 30-YEAR LIFE	$27.5	$42.6

RESULTS OF VALUE-IMPACT

(IN MILLIONS)

BWRS

(BASED ON IMPROVEMENT OVER UTILITY BASE CASE)

	IMPACT	VALUE	
		WITH EPG	ORIGINAL
UTILITY RULE	11.9	34.5	26.7
STAFF 3A	27.5	2.5	10.3
OR			
STAFF 4A	42.6	4.3	12.1

RESULTS OF VALUE IMPACT

PWR's

(IN MILLIONS)

(BASED ON IMPROVEMENT OVER UTILITY CASE)

	Incremental Value/Impact		
	Westinghouse	CE	B&W
Amended Utility Rule	0.9/2.8	6.4/5.4	5.2/5.9
Staff 3A	0.5/7.8	--	--
Staff 4A	--	1.4/15.2	1.4/15.8

VALUE-IMPACT RATIOS

	GE	WESTINGHOUSE	CE	B&W
AMENDED UTILITY RULE (COMPARED TO UTILITY BASE CASE)	2.9	0.3	1.2	0.9
STAFF 3A (COMPARED TO UTILITY RULE)	0.09	0.06	---	---
STAFF 4A (COMPARED TO UTILITY RULE)	0.10	----	0.09	0.09
HENDRIE RULE (COMPARED TO UTILITY RULE)	0.08	0.04	0	0

PROBABILITIES OF UNACCEPTABLE CONSEQUENCES

BEFORE AND AFTER UTILITY RULE

	GE	W	CE	B&W
BEFORE (SAI BASELINE)	1.3×10^{-4}	5.6×10^{-6}	2.7×10^{-5}	2.3×10^{-5}
BEFORE (NRC BASELINE)	2×10^{-4}	8×10^{-5} TO 10^{-6}	8×10^{-5}	8×10^{-5}
AFTER ORIGINAL GROUP RULE	4.1×10^{-5}	2.6×10^{-6}	5.7×10^{-6}	5.6×10^{-6}
AFTER AMENDED GROUP RULE	1.6×10^{-5}			

CONCLUSIONS

BY ADOPTING THE UTILITY ATWS PETITION:

- ATWS RISK WILL BE LOWERED SUCH THAT FURTHER ACTION IS NEITHER REQUIRED FROM A SAFETY GOAL PERSPECTIVE NOR COST EFFECTIVE.

- THE FOLLOWING MAJOR CONCERNS WILL BE MET:

    ELECTRICAL CMF (NOT W)

    EFFECTIVE PROCEDURES AND WELL TRAINED OEPRATORS

    AUTOMATIC AFW AND TT (IMPORTANT FOR OTHER TRANSIENTS)

    SDV MECHANICAL CMF

    INCREASED BORON RATE ON NEW BWRS

- INDUSTRY WILL AVOID

    COSTLY PLANT SPECIFIC DBA ANALYSES

    EXTENDED OUTAGES

    PRIMARY COOLANT BOUNDARY MODIFICATIONS

    INADVERTANT ACTUATIONS